The Dock and Harbour Authority

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Editorial Comments

The Port of Colombo.

The island of Ceylon became a self-governing Dominion of the British Commonwealth of Nations in February, 1948, and its premier port of Colombo is now entering an important phase of modern development, both as regards its port facilities and administration.

The early development of the port, to enable it to cope with increased trade, was retarded for several reasons, including the incidence of two world wars, and with the exception of certain breakwaters which were actually constructed, plans conceived in outline as early as 1902, did not take final shape until 1939. After further delay, they were again put forward in 1945, and details were given in the February, 1947, issue of this Journal. They have since been modified in the light of modern port practice and cargo handling methods, and works of construction conforming to the revised plans are now proceeding. This latest scheme is the subject of our leading article this month, and has been kindly contributed by Lt.-Col. Hernu, O.B.E., Chairman of the Port Commission.

It will be observed that, at present, although there is safe accommodation for ships of the largest tonnage behind the breakwaters, the port is essentially a lighterage port. Forty vessels can tie-up to screw-pile moorings, the average depth of water being 32-ft. at low-water ordinary spring tides, and the rise of tide 2½-ft. After considerable difference of opinion, the construction of deep water quays for transhipment of cargo has now been accepted as a general principle, which is, of course, in line with usual practice at the majority of Colonial and Dominion harbours. When the present works are completed, only export traffic, amounting to about one-third of the total tonnage handled, will continue to be handled by lighters.

The principal structure in the first phase of the construction scheme is the Delft Pier, which will provide four berths and a possible fifth. This pier, together with the marginal Customs Quay, provide, in our view, a significant example of the need for flexibility of design, i.e., the utility of both forms of berthing—as to which there are differing opinions—are both shown here to have their special application under certain site conditions.

The design of the quay walls is of the familiar " sliced " block work type, which provides a sturdy construction upon a good load bearing structure, while a feature of the scheme is the increase in transit shed and warehouse accommodation, with facilities for the use of mechanical cargo handling equipment. Road and railway facilities and access to the port have always been somewhat difficult at Colombo, because the main railway sorting yards are some miles away from the port, but rail and road improvements are now being planned, in view of the modern tendency towards an increase in freight haulage by road transport.

In regard to administration, the Port of Colombo (Administration) Act, which came into force in January of this year, constitutes the commencement of a new era in the history of the port, and as is pointed out in the article, the internal administration of the port is now, for the first time in its history, in the hands of the Port Commission. At the same time, however, while the provisions of the Act, in regard to port operation and decasualisation of labour, go far towards ensuring greater proficiency, the future success and efficiency of the port will greatly depend upon a reform of the present constitution, long overdue.

We are fortunate in being able to publish also in this issue, the Report of the Committee of Enquiry set up at the request of the Government of Ceylon. Its purpose was to inquire into various aspects of the port which might have a bearing upon the surcharge on freights, recently imposed by British shipping companies. This Report deals with the present difficult working conditions, and, while making a number of constructive recommendations, comes to the conclusion that many of the causes of delay in the turn-round of shipping are purely temporary, and will disappear when the improvements in the port, now in progress, are completed.

Another matter upon which the Committee expressed themselves, was the present constitution of the Port Commission, which they considered inadequate. We are entirely in agreement with the broad outlines of a proposed autonomous Port Authority, representative of all interests, working, however, in liaison with the Government regarding the financial and supply aspects of improvement schemes involving capital expenditure. This we regard as a necessary safeguard to ensure the elimination of a restricted or competitive outlook, if the port is to take its place in a properly integrated system of national transport. We expressed our opinion upon such points as these in our comments upon the " Review of Trade Harbours " in our October issue, and they are relevant to the present case.

It is to be hoped that a Port Authority on the above lines, which would be commensurate with the geographical and national importance of the Port of Colombo, and which has worked so well in Great Britain, the United States and elsewhere, will, in due course, be established.

Water Problems of London and the Thames.

No doubt it has occurred to many people, resident in London and the Thames valley, that in the winter there is too much water in the river and in the summer too little, and that it should not be beyond man's ingenuity to regularise the position.

Editorial Comments—continued

Last month, we published an outline of a scheme devised to provide a Contour Canal and additional supplies of water to London, from the Severn and the up-river area run-off which finds its way into the Thames, and we are now following that article with an account of the problems confronting the London County Council in respect of the prevention of floods in London and the lower-river areas.

From Mr. Chalmer's paper, which will be found on another page, it will be seen that the safeguarding of these districts from flooding, the main threat coming from the North Sea, has been one of considerable intricacy, the incidence of high flood levels depending upon a number of unknown quantities, together with the coincidence of several circumstances. That London is now safe from any predictable floods is due to a great amount of research on the part of many authorities and individuals, and readers will, we are sure, be much interested in the paper.

The safeguarding of the valley lands, through which runs the non-tidal up-river portion of the Thames, is a problem of equal difficulty, and if it can be resolved and at the same time, an increase in London's fresh water supply can be effected, so much the better. Several reservoir schemes to that end have been proposed, but the lack of suitable areas, which do not involve the sacrifice of valuable agricultural land, in which to impound water, probably renders this form of control and water supply impracticable entirely by itself. For those interested in the subject, it might be mentioned that in 1937 schemes for controlling the flows of the Thames and the Severn were outlined in a paper read before the Institution of Sanitary Engineers, by Mr. S. Bransby-Williams, M.I.C.E.

It is probable that the solution of these problems will eventually be solved by a combination of several methods.

Cargo Handling and Shipping Turn-round in Port.

The formation of the proposed International Cargo Handling Co-ordination Association, brief details of which were printed in our last issue, was duly confirmed at a meeting held recently in London. The meeting was surprisingly well supported, delegates attending from seven European countries and also the United States of America. An account of the proceedings will be found on page 264 of this issue.

In view of the small amount of publicity that had been given prior to the meeting, the attendance was encouraging and indicates that the sponsors of the scheme are on the right lines and that the need for such an Association, which hitherto has not been satisfied, has been felt for some years past by a number of port authorities and shipping interests. Also, as the title of the new body indicates, problems connected with cargo handling at ports, are international.

At the meeting, the need for action to accelerate the turn-round of ships in port was emphasised by several speakers, and any organisation that can help to achieve this desirable objective should be given every encouragement. There is no doubt, however, that the new Association is faced with a difficult and complex task, and as one speaker said, it will be criticised in many quarters, " because it is much easier always to criticise than actually to do something."

One outstanding problem which was freely ventilated at the meeting was that concerning the attitude of dock labour towards innovations in the industry and this important point, which in our view is the crux of the matter, was referred to by many speakers. It is disconcerting to learn that a communistic element has so much influence among port workers—an influence which is not confined to one particular country but which, unfortunately, is world wide. Reports of labour disputes at ports in Australia, New Zealand, America and Europe are all too frequent, and there seems little doubt that a careful plan of campaign has, for some years past, been deliberately carried out by Communist direction. Repeated warnings of these activities have been issued by the International Transport Workers' Federation, but owing to intimidation and other subversive methods by extremists, their warnings are largely without effect. In fairness to the workers, however, it should be mentioned, in passing, that restrictive and arbitrary practices are not confined to only one side of the industry, and the need for both employers and employees to take the fullest advantage of any negotiating and conciliating machinery which is available, cannot be over emphasised.

With regard to speeding up the turn-round of shipping in ports, it is obvious that co-ordination in cargo handling methods is essential if efficiency is to be attained, and ships are to be cleared with equal celerity from both " home " and " foreign " ports. Whether or no, the ship or the wharf, or both, should be equipped with the cargo handling aids, is a moot point, and is largely a question of economics, and here the new Association will have a fruitful field for investigation, and their findings and recommendations will be studied with interest.

At present, of course, many ports in the United Kingdom and in other parts of the world are still hampered by war damage, but once this severe handicap has been overcome, greater efficiency should result. Meanwhile, opportunity should be taken during the rehabilitation period to ensure that the lay-out of the quays and the equipping of them with cargo handling facilities should be on the most progressive lines. Here again there is room for a careful study of the best methods to be adopted.

The more the information concerning these problems can be disseminated, the greater will be the benefit to all concerned, and this Journal has persistently advocated that research and co-ordination among port and shipping interests is a *sine qua non* of efficiency in port working. In our view therefore, the new Association has been started at a most opportune time, and we wish the newly-formed Executive Committee every success in their endeavours.

Port Economics.

It will be remembered that from January 1947 to July 1948, we printed a number of articles on Port Operation and Administration by A. H. J. Bown, O.B.E., F.C.I.S., M.Inst.T., and C. A. Dove, M.B.E., M.Inst.T., and subsequently, these were reproduced in book form in collaboration with Messrs Chapman and Hall Ltd., the well known publishers of technical books.

We have since been asked whether we could arrange to publish a further series of articles on Port Economics which would be complementary to those which have already appeared, and which would be primarily for transport students who are sitting for examinations but who are at present handicapped by lack of up-to-date information on this subject. Mr. Bown has kindly agreed to write the further articles, which will be based upon a syllabus generally conforming with the Institute of Transport examinations. The first of these will appear next month, and it is anticipated that, ultimately, these also, will be printed in book form.

The efficient working of ports undoubtedly holds an important place in existing world economic problems—more important indeed than is perhaps generally appreciated. Literature on the subject is not very plentiful, and apart from a few text books written before the war, is mostly to be found in detached articles and papers. Also the many changes during the last decade in port working methods, and in the general trend of world trade, e.g., the increased demand for meat and other staple foods by countries with rapidly increasing populations, the production and transport of oil, and the development of new territories, has shown the need for more up-to-date information.

The student of port economics is, of course, faced with more involved problems than the elementary examples just quoted, so that the proposed series of articles covering all aspects of the subject will, we think, be welcomed by our readers.

Increase in Subscription Rates

The Publishers of " The Dock and Harbour Authority " regret to announce that, owing to substantial increases in the price of paper, printing, postages and overall production costs, it has been found necessary, for the first time since the Journal was founded in 1920, to increase the selling price to 2s. per copy plus 4d. postage. The annual subscription will be 26s. 0d., including postage to any part of the world, and the new charges will take effect as from 1st January, 1952. Current subscriptions will continue at the old rate until due for renewal.

The Port of Colombo

Extensive Development and Modernisation Scheme

By Lt.-Col. P. A. J. HERNU, O.B.E., M.Inst.T., F.R.G.S.

THE close of the first half of the twentieth century marked another milestone in the 2,000-year-old history of the Port of Colombo, when the present plans for its modernisation were passed with the signing of the 56 million rupee contract on the 28th June, 1950.

From the earliest times, Colombo, as an open anchorage, offered protection to the trading fleets of the Egyptians, Greeks and Romans and in later centuries, to the ships of the Portuguese, Dutch and English. With the dawn of the 19th century, Colombo had consolidated its position of importance on the shipping routes of the eastern hemisphere, as reference to records published in 1830 reveals that 130 vessels of an aggregate tonnage of 20,000 made use of its anchorage. Four decades later, when the number of ships calling at Colombo had increased thirteenfold, it became evident that the construction of a safe and commodious harbour to give protection to shipping exposed to the fury of the monsoons, was an urgent necessity. Up to that time, extreme caution was necessary to pilot a ship into the anchorage on account of sunken rocks, sandbanks and coral reefs, and vessels of any size were, therefore, compelled to anchor from one to two miles from the shore. The proposals for the development of the port received further impetus, when the Suez Canal was opened in 1869, thereby opening up additional trade possibilities for Colombo.

Creation of Artificial Harbour.

The history of the Port of Colombo, as an artificial harbour, began soon after this date, for in 1874, after close and prolonged investigation, the preliminary work for the construction of the South-West Breakwater was put in hand and the following year saw the laying of the foundation stone by King Edward VII, then Prince of Wales. With its completion in 1885, the former open roadstead of Colombo was changed into a harbour that was sheltered on its most exposed side from the South-West Monsoon.

The continued economic expansion of Ceylon and the ever-increasing demands of shipping calling at Colombo, however, required the construction of further protective works. The construction of the North-East Breakwater and later, the North-West Breakwater (known as the Island Breakwater) were completed by the end of 1906. Finally, in 1912, an extension arm of the South-West Breakwater was constructed, thus making Colombo a haven of 640 acres of completely sheltered water for shipping. These improvements have yielded handsome dividends, for the nett tonnage of shipping calling at Colombo spiralled upwards from two hundred and seventy thousand in 1871 to approximately twelve and a quarter million in 1950. Exactly 75 years after the first stone was laid to transform it from an open roadstead into a protected harbour, Colombo passed the threshold of its second phase of development.

Early Port Construction Plans.

The first plans in connection with a scheme of development of the port with alongside berths were drawn up as early as 1902, while the breakwaters were being built. These plans, however, were turnd down by the Harbour Board, the controlling body of the time. In 1908, modified plans were again presented to the Board, only to be rejected a second time. It was then after an interval of almost ten years, in 1917, that a start was again made but progress was so slow, that it was not until 1926 that the plans began to take shape. A further period of ten years elapsed before they were ready, but the deliberations which followed with the Consulting Engineers had not proceeded far beyond this stage, when war intervened in 1939 and once more the work of planning was laid aside.

At the end of 1945, with the cessation of hostilities, the Port of Colombo was at the crossroads, when a decision of considerable importance had to be made. It was a question of either attempting to return to normal peace time trade with methods of handling cargo, which had been obtaining from the very beginning of its history, or whether new methods, in accordance with modern port practice, should be introduced. In other words, it was a matter of policy of handling cargo with lighters by purely manual labour, without direct communication between ship and shore, or a policy of mechanical handling of cargo at alongside berths. Furthermore, the problem of the gradual deterioration in the time taken for the turnround of ships in the port had to be faced squarely. Of the several factors responsible for this state of affairs, the loss during the war of 30% of its lighter fleet, on account of enemy action, the lack of maintenance, due to short supply of teak and other materials, as well as the poor output of work by labour, were probably the two main causes. Further, all attempts to improve the output of work by the introduction of mechanical aids for handling of cargo on shore were handicapped, due to the narrowness of the lighterage wharves, and the old type of transit sheds, encumbered as they are by pillars and stanchions. For these and other reasons, therefore, it was essential to draw up plans for the construction of alongside berths to meet modern requirements of shipping.

Need for Modern Lay-Out.

The Second World War probably did more to stimulate Port Authorities in their search for improvement of port facilities than has any other event since the turn of the century. The acute shortage of shipping during that period strained the facilities of many ports of the world to their utmost, as the quick turn-round of ships in a port was then of vital importance.

The narrowness of quay aprons and transit sheds, the encumbrance of transit shed floor space with pillars and stanchions, the narrowness or complete absence of loading platforms to the rear of transit sheds, etc., were all accentuated when the introduction or the greater use of mechanical handling equipment was brought about. Furthermore, the tendency in many ports for cargo to be carried by road transport rather than by rail, coupled with the greatly increased carrying capacity and, therefore, the size of the road vehicles, brought to light the inadequacy of road access and parking facilities on piers and quays. If to this is added the over-all increase in the carrying capacity of cargo vessels since the beginning of the last decade, as well as the improved cargo handling gear, such as faster working winches and four cargo working booms for " long " hatches, with which the modern ship is equipped, the problems which faced many Port Authorities when hostilities ceased were as numerous as they were complicated.

New Scheme Prepared.

Bearing these factors in mind, the attention of the Colombo Port Commission was again focussed in 1945 on the pressing question of further development of the port and a determined and energetic effort was made to produce plans with the utmost speed. The old plans were scapped and an entirely new scheme was prepared to meet the real needs of Colombo, which is a transit port as distinct from a terminal port on which premise, apparently, the earlier plans had been based.

A planning team of three, composed of the Master Attendant, the late Commander D. C. G. Neish, R.N. (Retd.), the Harbour Engineer at the time, Mr. T. A. Owles, M.I.C.E., and the Chairman, Lt.-Col. P. A. J. Hernu, drew up the broad plan of development. It was then submitted to the Consulting Engineers to the Port, Messrs. Coode, Vaughan-Lee, Frank & Gwyther of London, for preparation of detailed plans and contract documents. When completed, world-wide tenders were called for, and in all seven well-known firms of contractors, French, Dutch and Danish, submitted tenders. The contract was finally allotted to the lowest tenderer, Messrs. Compagnie Industrielle de Travaux of Paris (a combine of Entreprises Schneider and Etablissements Billiard). As

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stated earlier, this contract was signed on the 28th June, 1950. And so, only four and a half years after commencement of planning, this very large development scheme became a reality.

Details of Development Scheme.

The scheme, which comprises four distinct major works, is phased in two main parts. The cost of the first phase is Rs.33,000,000, and that of the second Rs.23,000,000. At first sight, the capital cost may seem very high, but it is due entirely to the fact that Colombo starts from scratch, whereas other Eastern ports have, to a greater or lesser degree, alongside berths, which were built over a long period. If deep-water quays for alongside discharge is accepted as a principle, because of present-day conditions and requirements, the cost of an effective and comprehensive plan for a port of the size of Colombo, is therefore, high. In other words, alongside handling of ships

The main crusher of the quarry, which is being utilised by the Port Development Scheme Contractors, with the secondary crusher on the left of the photograph. The potential output of this plant is 1,200 tons of crushed stone and metal per day.

is a policy and a policy must have certain minimum requirements in order to be effective.

The plan of development, which is now being carried out, has been generally hailed as being the soundest method of providing the port with alongside berths, not only from the point of view of efficiency in operation, but also as a minimum requirement for the effective trade of the port. The length of time required to carry out the whole scheme is estimated at three and a half to four years, at the end of which time, more than two-thirds of the handling of import cargoes will have switched over from lighterage to direct discharge from ship to quayside.

The works to be constructed are as follows :—

Part I.

(a) **North-East Breakwater Quay (Mutwal Quay).**

The existing North-East Breakwater is to be converted into a solid quay 1,242-ft. in length and 185-ft. in breadth, giving two berths for cargo ships, each with its transit shed. At the root of the quay, a large storage warehouse will be provided, as well as covered and open storage space.

(b) **Oil Dock.**

The length of the north pier of the Oil Dock will be 1,278-ft. and that of the south quay will be 1,155-ft. The dock will be dredged to a depth of 36-ft. and will be equipped with a floating boom across its entrance which, in the event of fire, will prevent the dangerous spreading of oil or petrol over the rest of the harbour. This dock will accommodate two tankers and will be equipped with pipelines leading to the Oil Depot, seven miles away, where the main storage tanks of the various Oil Companies are situated.

(c) **Lengthening of the Guide Pier or South Quay of the Oil Dock.**

The Guide Pier will have a total length of 1,200-ft. and will permit two vessels to berth alongside, instead of one, as at present, to receive supplies of fuel oil and fresh water from the pipelines on the quay. It will also be equipped with pipelines for loading ships with bulk coconut oil from the storage tanks nearby, as well as bulk latex from storage tanks which are now being built.

(d) **Delft Pier.**

This 425-ft. wide pier will be built on the site of the present Passenger Jetty and will extend in width as far as the entrance to the Harbour-to-Lake Canal. The eastern quay will be 1,384-ft. in length and will have a depth of 33-ft. of water, providing two berths for large cargo steamers. The western quay will be 1,352-ft. in length and will provide two further berths for cargo vessels. Each of these berths will be provided with large modern transit sheds. The construction of this pier also makes provision for two to three berths for coastal vessels, dependent on the Monsoon.

Part II.

South-West Breakwater Quay (Customs Quay).

The length of this quay will be some 3,000-ft. It will be 400-ft. in width and will have a depth of 36-ft. of water alongside and will provide berths for 4 or 5 ships. This quay will be similar in construction to the North-East Breakwater Quay (Mutwal Quay) and will be fully equipped with rail and road facilities. Large and up-to-date transit sheds with special accommodation for passengers will be provided on each berth.

The off-take of cargo from the transit sheds on the Delft Pier and the South-West Breakwater Quay (Customs Quay) will be provided for by the construction of a large storage warehouse in close proximity.

The Scheme will, therefore, provide some 10,000-ft. of deep-water quays, or 15 berths, as well as 2/3 Coaster Berths. Of the 15 deep-water berths, two will be located inside the New Oil Dock.

Construction. All deep-water quays will be of blockwork construction with a mass concrete superstructure with moulded ashlar facing. The blockwork is of the " sliced type " upon a rubble foundation of a minimum thickness of 4-ft. The weights of the rubble deposited vary between 28-lb. and 5-cwt., and the foundation is finally screeded by divers to a level surface with 2-in. gauge crushed stone, before the bottom blocks are set. The " sliced blockwork " is set at an angle of 67½° to the horizontal and the courses are 5-ft. in height. There are eight courses in the block wall with a top breadth of 14-ft.

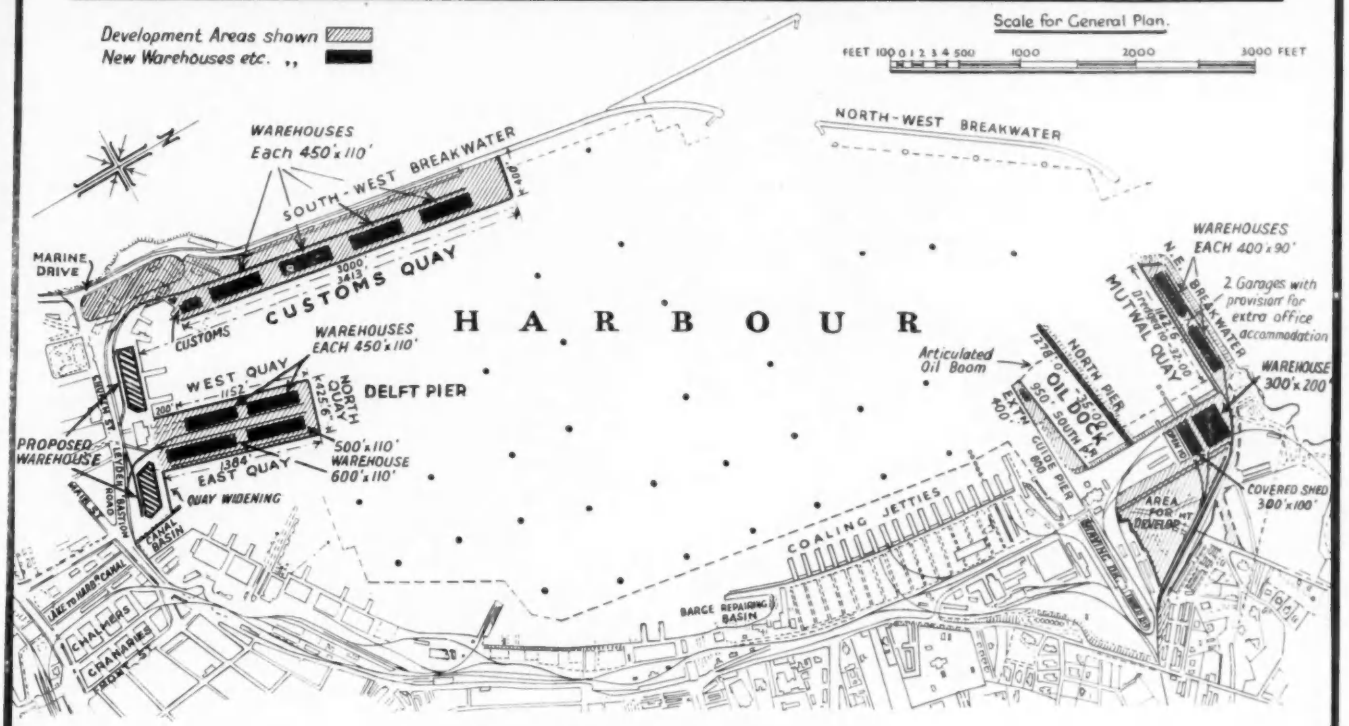
The blocks are of the " tongue and groove " type in weights varying between 8 tons and 14 tons. They are all set by divers using the Fidler System of lewis bars.

All junctions with existing work are made with horizontal blockwork, which is stepped or bonded into the sloping courses, and all roundheads and return walls are constructed with horizontal blockwork upon mass concrete foundations.

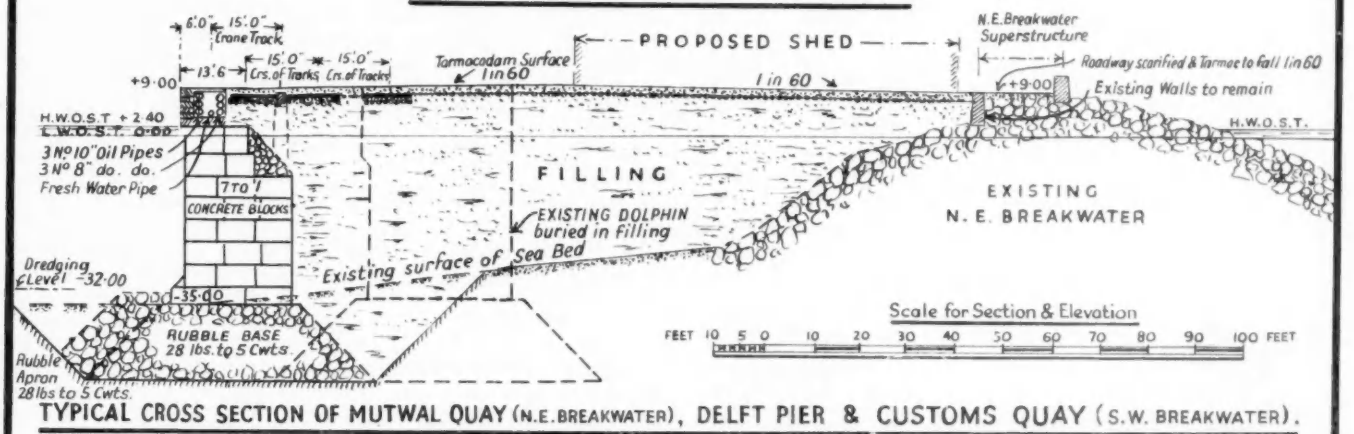
In order to facilitate the work of the port, the section of the Customs Quay, in front of the new Customs Shed, will be constructed in mass concrete inside a steel sheet piled cofferdam. The section of the mass concrete wall will be completed at the correct slope, so that the sliced blockwork can be set to full section from that point.

The Contractors have adopted a dual system of blocksetting, using both floating cranes and land based cranes, the general system, however, being by floating craft. By these methods the Contractors hope to avoid delays, due to the monsoons, and they expect to work continuously to reach the total of some 37,000 blocks set.

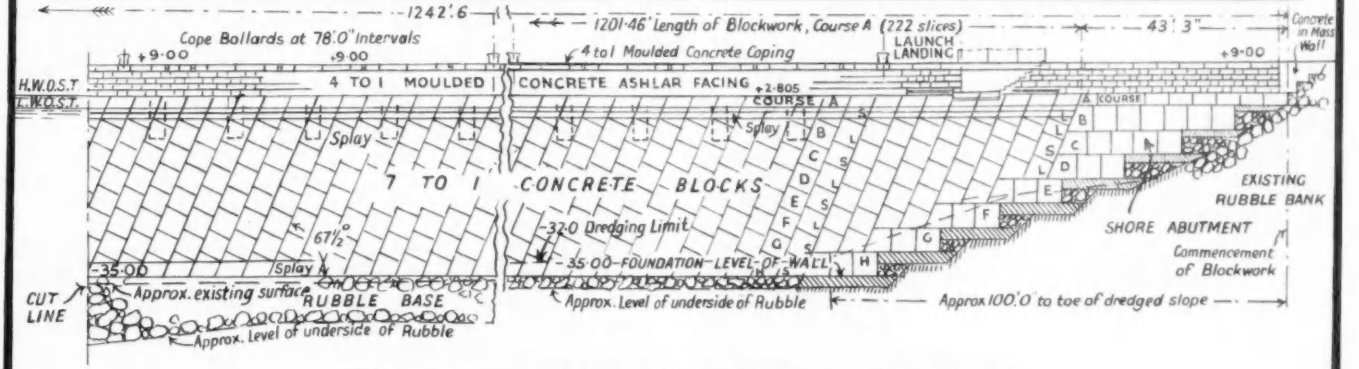
PORT OF COLOMBO DEVELOPMENT



GENERAL PLAN OF DEVELOPMENT.



TYPICAL CROSS SECTION OF MUTWAL QUAY (N.E. BREAKWATER), DELFT PIER & CUSTOMS QUAY (S.W. BREAKWATER).



PART ELEVATION OF MUTWAL QUAY (N.E. BREAKWATER).

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Two of the Coaster Berths will be of cylinder construction with reinforced concrete decking, the cylinders being 7-ft. in external diameter.

The level of the quays will be 9-ft. above L.W.O.S.T. and they will be fitted with Cope bollards, provision for fuel oil, diesel oil and water pipes having been made.

The quay aprons are 50-ft. in width, the rail tracks being flush with the surface of the quay.

Steel framed transit sheds will be provided on all quays and will be constructed to the maximum economical clear spans. Warehouses will be provided adjacent to the quays to enable the transit sheds to be cleared, thus avoiding the time lag of uncleared goods.

Lighting will be of the most modern type, both inside the sheds and on the adjacent quays. The ventilation of the sheds will be of the automatic type and of the latest design.

The Oil Dock will provide berthing for two tankers, the depth alongside being 36-ft. at L.W.O.S.T., and the area will be enclosed with a floating oil boom fitted with a chemical fire extinguisher.

Ancillary Works. It has been established by observation, as well as by tests carried out in the hydrographic model of the harbour, that protection will have to be given to the South-West Breakwater Quay (Customs Quay). It is, therefore, proposed to construct a rubble mound, parallel to the South-West Breakwater, which will break the heavy swell that beats against it during the South-West Monsoon and which will in the course of years, as has been proved at the junction of the South-West Breakwater and its extension arm, become filled with sand and provide valuable reclaimed land for development.

The possibility of providing an alternative route by which rail traffic from the port can be linked up with the main line of the Ceylon Government Railway has also been explored in detail, and it has been decided to construct a tunnel from the port premises to the main line of the railway system, which will shorten the distance between the port and the railway yards by about four and a half miles.

Rapid Progress of Construction.

When the contract documents were completed, tenders were called for from firms of Harbour Construction Engineers of international repute and seven firms of the following nationalities submitted quotations :

4 French, 2 Danish, 1 Dutch.

The absence of British firms from the tenderers was undoubtedly due to the fact that the question of relief from double taxation had at that date (April 1950) not been settled between the two Governments. The tender accepted was that of the French contractors, Compagnie Industrielle de Travaux, a combine of the concerns, Entreprises Schneider and Etablissements Billiard, which have carried out harbour construction and other public works in Europe, North Africa and South America.

Blockyard set up by the Contractors. The four gantry cranes for the movement of blocks are seen in the centre of the photograph and the silo and concrete mixer unit on the left.

As soon as the contract was signed in June, 1950, the French Contractors proceeded immediately to ship a very large quantity of plant and mechanical equipment from Europe, so that the work could be commenced without delay. Before undertaking works of the dimensions of the Port Development Scheme, stone supplies had to be assured. The Mahara Quarry, situated some ten miles to the north of Colombo, now handed over to the Contractors by the Colombo Port Commission, appears to meet all requirements, having both rail and road connections with the Works. The quarry has a well developed " face " with the overburden thrown well back and although the floor is inclined to be hot and humid, the rather beautiful approaches hardly suggest to the visitor any sort of discomfort and certainly not the mass of modern machinery installed there. It was decided to carry out the work at the quarry in two stages, firstly to provide a small Primary Plant to meet the requirements of temporary works and, in the meantime, to assemble the Main Plant.

The erection of the Primary Plant was started in September 1950, and was in operation in the following February. All steelwork and machinery, some 50 tons, was brought from France. This Plant is based upon a 10-in. rotary crusher with vibrator screens. The crushed stone, ranging from zero to 4-in., travels by means of belt conveyors to bins. The output of the plant is between 90 and 100 cubic yards of crushed stone per day. It is electrically operated and will be kept to meet an emergency now that the Main Plant is in operation.

The assembly and erection of the Main Plant was commenced in January, 1951, and it came into use at the end of July, 1951. Before the plant could be erected, it was necessary to carry out rather heavy earth excavation and banking. The main structure has four floors above the bins and required some 300 tons of structural steelwork. To this must be added all the machinery and belt conveyors, all of which came from France.

As the plant was erected, all parts were carefully numbered and fitted to facilitate their removal upon the completion of the Works.

The Main Crusher Plant is based upon one 18-in. rotary crusher and two secondary rotary crushers, 8-in. and 10-in. respectively. Suitable stone is delivered to the main 18-in. crusher. The crushed stone (zero to 8-in.) is passed by means of elevators and belts to the top of the structure, and so through feeders to the rotary screens. The reject, above 4-in., can either be directed to the secondary crushers and so to the screens again or to bins to be used as finer grading in the rubble bottoming in the quay wall foundations. The aggregates screened out between 3/16-in. to 4-in., are directed to silos and thence transported to the blockyard and other places at the site of the works. The whole plant is electric and the output is about 100 cubic yards per hour. Space prohibits a more detailed description.

Every effort has been made to reduce the unskilled labour employed and machinery has been introduced at every stage of the work. The drilling at the quarry face is pneumatic and after blasting, the stone is reduced by secondary blasting to meet the requirements for the rubble foundations and the crushers. As far as possible, all transportation has been mechanised. Thus, apart, from French mechanics, there will be about 120 semi-skilled men employed at the quarry.

The total output of the quarry, that is rubble and stone aggregates, will be in the region of 1,200 tons per day. This could be increased by using the Primary Plant.

Road and Rail Improvements. The question of providing additional road and rail access to and from the harbour has been considered in detail. With the advent of alongside berths in the southern part of the harbour, it is anticipated that large quantities of cargo will be concentrated in that area. As the only approach roads to this area are quite inadequate to deal with the volume of traffic, even at the present time, it is proposed to solve this problem by the construction of a 40-ft. roadway having access to the har-

The Port of Colombo—continued

The first of the four main works to be undertaken under the Port Development Scheme was the North-East Breakwater Quay, which will be known as the Mutwal Quay. This photograph was taken four months after commencement of work and shows the considerable progress made by the Contractors.

bour at the root of the South-West Breakwater and proceeding along the coast line, thereby by-passing the busy commercial centre of the town. As at present planned, the Marine Drive, as it will be called, will have the added advantage of giving access to the port area, outside the Customs premises, to the citizens of Colombo, who have long been deprived of seeing the shipping in the port and having a more intimate knowledge of one of the country's most valuable assets. It should also prove one of the most beautiful features of the city, as it will skirt the seashore from Battenburg Battery to the end of Queen Street opposite the House of Representatives. One of the attractions of that marine drive will be an imposing lighthouse embodying many Sinhalese architectural features. It will take the place of the well-known Clock Tower Lighthouse and its automatic electric light will be one of the most powerful in Eastern waters.

The first marine structure to be undertaken by the contractors is already well in hand as some 500-ft. of quay wall of the North-East Breakwater Quay (Mutwal Quay) has appeared above the water level. The necessary dredging of the foundations of the north pier of the Oil Dock is practically complete and work on the foundations will shortly be commenced.

As instructed by the Resident Engineer, the Contractors have also commenced the work of demolition in the south-west corner of the harbour for the construction of the coffer-dam, which marks the beginning of the South-West Breakwater Quay (Customs Quay). The driving of the sheet piling for the coffer-dam was started at the end of October.

It will, therefore, be seen that the commencement of work of development is well in hand and it is hoped that the first two berths on the North-East Breakwater Quay (Mutwal Quay) will be ready for use by cargo ships in mid 1952.

Port Administration and Operation.

An important matter affecting the future of the Port was the completion of the Port of Colombo (Administration) Act, which provides for the Port, up-to-date machinery for its administration. For the first time since the inception of this Port seventy-five years ago (except for the war period when Defence Regulations were framed to give the Port Commission all the necessary powers), the administrative authority in the Port is vested in the Port Commission. Many of the powers enforced under the Defence Regulations are retained because they enable the Port to function with maximum efficiency; for instance, the landing of cargo will continue to be allocated by a Port Working Committee, which ensures that the full resources of the Port are utilized. Another feature embodied in the Act is the de-casualisation of Port labour by such measures as registration of labour, the payment of a stand-by wage and the formation of labour reserve pools.

The Act was passed on March 17, 1950 with little discussion in Parliament or the Senate, and thereafter the considerable task of framing Regulations had to be completed so that the Act could be brought into force on January 1, 1951.

The total visible trade of the Port for the year 1950, amounting to 4,846,667 tons, constituted an all-time record.

A serious effort is being made to attract transhipment trade to Colombo. Apart from the fact that the Port is extremely well situated geographically for this type of business, it is hoped that ship-owners will also be interested in taking advantage of the reduction in Port dues on ships carrying transhipment cargo. The building up of new business is naturally difficult and up-hill work. It is hoped, however, that with the completion of alongside berths and better facilities for landing cargo, this trade will become far more important than it is at present.

The Port of Colombo—continued

It is the aim of the Port authorities to encourage ship-owners to take oil bunkers in this Port, as its favourable geographical position, and the more efficient and economic facilities envisaged under the Port Development Scheme, should go a long way to offset any small differences in bunker prices obtaining elsewhere. It is obvious from the increases registered each year in the number of ships that bunker here, that Colombo is becoming more and more popular as a bunkering port. The total of 1,439 ships which took oil bunkers here in 1950 showed a 60 per cent. increase over the 1949 figure. There was, however, a decrease in coal bunkers, due to the falling off in the number of coal burning ships.

Passenger traffic again showed a considerable increase, and an average of over 1,000 passengers per day passed through the Port last year—a 50 per cent. increase over the figure for 1949.

Improved Financial Position.

The task of building up the present sound financial position of the Port Commission was not easy. At the end of the war the excess of revenue over expenditure was far from satisfactory. In fact, in the Financial Year 1946-47 the excess of revenue over expenditure was only just over six lakhs of rupees, but the commercial accounts showed a loss. It was obvious that Port dues, warehouse rent and other Port charges were not based on a post-war economy and had not moved with the increasing costs of wages, materials and equipment. Steps were immediately taken to carry out an exhaustive examination of this problem, and the new rates were introduced on March 29, 1949. It is now possible to see the results achieved during the past financial year, as although expenditure has risen during the past three years, the excess of revenue over expenditure has increased from six lakhs to nearly five and a half million rupees.

Encouraging Future Prospects.

In concluding this survey of the much needed improvements necessary to increase the efficiency of the Port of Colombo, it must be remembered that a port's main business, as in ordinary commercial undertakings, is to give good economic service to its customers; to the shipowner—safe berthing for his ship, efficient bunkering and provisioning, ship repairing facilities and, most important of all, a quick and economic turnround of his ship; to the importer and exporter—safe, economic and efficient handling of their cargoes.

It follows, therefore, that the development of the business of a port should be one of the primary functions of its Authority. Given the necessary powers of co-ordination and control of the port and its administration, the Port Authority is properly equipped to plan, as a commercial undertaking, its development in conjunction with the users, be they shipowners, port operators, railway and road transport companies or importers or exporters. With this co-ordination and central control, it is possible to plan new developments to meet potential requirements 20 or 30 years ahead with one object in view, the increasing of the trade of the port for the benefit of the country in general and the port community in particular.

When the present scheme of development of Colombo is completed and the administration of the port placed on a sound footing, Colombo will undoubtedly be one of the most efficient ports in the East. If to this is added its enviable geographical position on the "Crossroads of the East," the Port of Colombo can at long last look forward hopefully to the future and the important part it can play in the material progress of the nation.

Aerial View of the Port of Colombo.

Improving Ship Turnround at Colombo

Report of Committee of Inquiry

In response to representations recently made by Ceylon to the British Government against the surcharge on freights to the Port of Colombo imposed by British shipping lines, a Committee of Inquiry was appointed with the following terms of reference:

(a) to inquire into the turnround of ships in the Port of Colombo, with particular reference to:
  (i) methods of handling cargo and supervision thereof;
  (ii) effects of post-war imports of bulk cargoes on the general operations of the Port;
  (iii) effects of the increased number of importers in the post-war years as compared with pre-war period;
  (iv) effects of (ii) and (iii) on transit shed accommodation and to investigate the causes of delay in the turnround of ships, if any;

(b) to suggest suitable remedial measures if it is proved that delays to shipping exist.

The members of the Committee were Mr. P. E. Millbourn, C.M.G., Adviser on Shipping in Port at the British Ministry of Transport, and Mr. A. E. Christoffelsz, and they commenced their inquiry on September 3 last. They made a full investigation into the working of the Port of Colombo and inspected the operations of cargo discharging and handling, both in ships within the harbour and on the quays and in the warehouses. They also discussed with all those concerned, the day-to-day operations of the port, and after obtaining information and advice from every source available, finally issued a Report, which was published early in October.

In their Report, the Committee call attention to the major works (described in the foregoing article), which are under construction within the port area and state that the difficulties which are being felt at the present time should, in their opinion, disappear when the new works are completed. They consider, therefore, that the present troubles may be looked upon as temporary and, providing certain actions which they recommend are taken in good time, they believe the Port of

The Port of Colombo—continued

Colombo will regain in the near future the reputation for expeditious handling of ships and cargoes that she held until recently. They understand it is the intention of the Port Commission that when the new facilities are available they are to be used for import cargo and that all export traffic will continue to be handled by lighter as at present. With this they fully agree.

H.M. Customs Passenger Jetty—Port of Colombo.

Cause of Difficulties.

The difficulties which the port has experienced in the past few years are stated to be due, firstly to the considerable increase in the volume of import cargo coming to Ceylon, which shows no signs of abatement and, secondly, to the change in the manner in which they are imported.

General cargo has increased from 1,140,000 tons in 1939, to 1,550,000 tons in 1950, while food cargo, i.e., rice, sugar and flour, in bagged form, rose from 692,000 tons in 1939, to 834,000 in 1950. Certain other cargoes, not included in the above figures, have also shown a marked increase, while only the imports of coal have decreased from 470,000 tons in 1939, to 362,000 tons in 1950. Post-war changes in commercial practice and world conditions generally have had the effect of increasing the number of importers of general cargo from 600 prior to 1949 to 1,400 in March, 1951. Food commodities in bagged form are now acquired by bulk purchase through Government agency and not on account of private traders, as was the case before the war, resulting in anything but an even flow of these commodities to the port.

The facilities within the port for handling cargo have not changed very materially since 1939, except in regard to the type of labour employed. Prior to 1939 this labour consisted mainly of non-Ceylonese men; but during the last few years there has been a diminution in the proportion of this type of labour, and they have been replaced by a labour force which by their physique and stamina are not comparable with their predecessors. Further, the terms and conditions for the employment of dock labour have changed and do not appear to be most conducive to obtaining the most satisfactory results. A further fact is the decrease in the lighter capacity by some 30 per cent. since 1939.

Although the port is not laid out to obtain the fullest advantage from the use of mobile handling equipment, nevertheless, there is scope for its use in certain operations and there is no doubt that an increase in the tonnage handled would result if more machinery of this type were adopted. The Port Commission have on order a number of mobile cranes and the Committee hope that others concerned with the movement of goods, both inside the port and in the premises outside, will follow this lead.

With regard to the heavier arrival in post-war years of food imports in bagged form, which has imposed a severe load upon the port's transportation and transit shed facilities, the Committee stress the importance of their discharge and transport beyond the confines of the port to warehouse accommodation, or to areas of consumption in the quickest possible time.

There is no doubt that the regular arrivals of the Government-purchased foodstuff cargoes on a phased programme, would materially assist in reducing delays to all shipping using the port and ensure that the transportation services operated to maximum efficiency. In the Committee's opinion, the Director of Food Supplies and the shipping companies should jointly continue to make every effort in this direction, since the advantages of an orderly flow of cargoes into the port are great and, in their view, this part of the problem is not without a solution.

Conditions and Arrangements of Working.

The arrangements for the employment of dock workers and the structure of wage rates, particularly in regard to the differential between payments for stand-by duties and actual work are, in the Committee's opinion, unsatisfactory. They therefore suggest that stevedoring and landing and wharfaging companies should maintain sufficient labour on a permanent basis which will take care of the normal run of work in the port and the pool should be of sufficiently large proportions to provide for occasions when the work is abnormally heavy. Recourse to the use of casual labour should be most exceptional and only used as a last resort. The opportunity for all classes of labour to work at piece work rates, when such are practical, is desirable. There is a marked tendency on the part of the stevedoring worker, in particular, to use little effort during the day, so that he may work long overtime hours at night, when conditions are more congenial. The Committee consider, however, that a shift system on an 8-hour period with a maximum of two hours overtime, would be more satisfactory and less costly basis upon which to work.

With reference to cargo handling arrangements the Committee suggest that, having regard to the changed conditions which are likely to take place when the new port works already referred to come into being, the time is ripe for a detailed investigation as to whether the present method of employing a number of firms, particularly for lighterage and landing, is the best. In their view, there are too many of these companies and the responsibility of the Port Commission to see that they supply an efficient service to the public is a difficult one. They think it worthwhile that consideration is given to the employment of one or, at most, two contractors for those duties.

The almost complete absence of warehousing accommodation as opposed to transit shed accommodation, both in the port area and in the city of Colombo itself, creates a serious handicap to efficient port working. The Committee examined possible sites for the construction of such a building and suggest the most suitable site is that now occupied by Chalmers Granaries, a part of which can be used for the erection of a modern multiple-storied warehouse for the storage of foodstuffs in bagged form, particularly rice, as well as general cargo, and which would have both water, road and rail access for incoming and outgoing traffic. The bagged rice discharged overside into lighters, in which the process of fumigation can take place, can then be brought direct to this ware-

The Port of Colombo—continued

house, where mechanical handling equipment could effect discharge at a rapid rate. Delivery from this warehouse to road and rail could also be made by chute in an expeditious manner and with the minimum labour. Similarly, general cargo remaining in transit sheds beyond a reasonable time could also be transferred to this depot.

Autonomous Port Authority.

When considering the present structure of the Port Commission, and the manner in which it functions, the Committee noted that there is a shortage of technical officers, which must have a detrimental effect on maintaining efficiency in the working of the port. They also noted that various formalities, involving in some cases long delays, have to be observed in the purchase of equipment, machinery, etc. They think that the present set-up is not an ideal one for the control and operation of a port of the size and importance of Colombo, particularly with the large scale developments now taking place.

" We are of the opinion that the present time is appropriate for the formation of a Port Authority with a considerable measure of autonomy vested in it, and free from Governmental departmental control in its day-to-day operations. We have in mind a Port Authority consisting of a Board of Members responsible for guiding the policy and development of the port and who would be representative of shipping, commercial, Governmental and other interests, and with a Chairman nominated by Government. Acting under the direction of this Board, would be a senior-executive officer in the position of General Manager, who would be responsible for all executive work."

Book Reviews

Year Book of Harbour Construction Society (Jahrbuch der Hafenbautechnischen Gesellschaft) Vol. (1941-1949). Publishers Springer-Verlag, Berlin, 6 plates, 124 illustrations, 235 pp. Price D.M. 40.

The printing and the binding of this new German volume is the best the writer has seen from post-war Germany, and is equal to the pre-war standard of this famous publishing house. Besides a number of short articles devoted to the reconstruction of several harbours and to the modern radio aids to navigation it has several contributions of importance by well known maritime engineers of which the following are of particular interest.

" Dry Docks and Lock Construction " by Dr. A. Agatz.

" Wave Impact on Moles and Breakwaters " by Dr. E. Bruns.

" Centralization and De-centralization of Harbour Planning of the Neckar Canals " by Dr. R. Fritzen.

" The Economical Layout of the Coal Export Facilities of the Rhenish-Westphalia " by Dr. Hans F. Oehler.

Dr. Agatz who is well known in this country displays his usual acumen in an excellent classification of the construction features of dry docks and gives a comprehensive tabulation of locking chambers of the European seaboards. Although he neglects to include several of the more recent examples of modern construction, such as the Sydney and Cape Town dry docks, and the great improvement latterly of lock closure his article is of great utility to harbour engineers.

The contribution of Dr. Bruns on Wave Impact shows that the author has been to great pains to obtain world-wide sources of information relevant to the computation of reflected wave pressure (clapotis) on walls and breakwaters. He gives tables of direct full scale dynamometrical measurement, and compares the analytical arguments of 25 different formulæ. He also compares, stage by stage, the arithmetical results of their application to specific cases by figures and graphs. The great diversity of the computed results shows the lack of thorough scientific research into this elusive problem and emphasizes the great need of caution in applying any one formula, without careful scrutiny of the assumptions of the originator. In such circumstances it is advisable to use the simplest solutions, which appear to be those of Sainflou, Antonelli, and the Belgian (International) Navigation Congress. They differ but slightly in the majority of cases, and have the advantage of having been checked by competent authorities on actual breakwaters.

The treatment of the pressure arising from breaking waves is not so thorough. The author mentions only two authorities, Wey and Hansen. The excellent researches of Brigadier Bagnold on models and his brilliant analysis of the mechanism of the break-blow are not considered nor yet are the full-scale measurements of Luigi Luiggi on the Genoa Mole and the more recent developments during the war period.

The analysis of the inter port groupings of the Neckar Canal systems is developed with keen insight by Dr. Fritzen. The same may be said of the considerations and the arguments adumbrated by Dr. Oehler who deals with the general arrangement and equipment of coal handling and transport of the canal systems of Rhenish-Westphalia. Both these papers show that the authors have particular aptitude in marshalling their facts and deductions into logical and effective conclusions. This volume deserves a place on the desk of maritime engineers with knowledge of the German language.

R.R.M.

Coastwise Shipping and The Small Ports, by P. Ford, Ph.D., B.Sc. (Econ.), and J. A. Bound, B.Sc. (Econ.). Published by Basil Blackwell, Oxford. Price 10s. 6d.

The aim of this book is to investigate the place of the small ports in the transport system of the United Kingdom and the national economy as a whole.

Coastwise shipping and the smaller ports of Britain together form an important system of transport, and a proper consideration of them is urgent because of the possible effects of other aspects of the Transport Act, 1947, besides the nationalisation of some of the ports and of the railways and road transport.

The exigences of war made the importance of the small port obvious. As stated in the Preface to the book, State policy, aiming at exercising " a substantial influence on the location of new industrial development," to use the terms of the White Paper of 1944 on Employment Policy, could scarcely leave out of account the docks and harbours of the areas to which the new factories were to be guided. But small ports are and must be largely concerned with coastwise shipping; their work and fortunes are bound together.

In an examination of the economic functions of small ports, we have to think not only of the individual ports and of any special circumstance of natural feature, resource or of industry which may give rise to their particular inward and outward traffic, but of their place in the national transport system. For this reason, amongst the questions requiring an answer are the following :

1. What are the main coastwise traffic routes and what commodities make up the traffic? That is, what trade or industries do coasting ships serve?

2. What proportion of the coastwise traffic is handled by " large " and " small " ports respectively?

3. What are the special circumstances which determine the originating traffic and the inward traffic of each port? What is the relation of each port to its little hinterland of productive industry or of consuming population?

4. Since the use of small ports must depend largely on coastwise shipping, what are the factors affecting the loading, relative efficiency and costs of coastwise shipping?

5.—What is the relation of the coasting trade to alternative inland routes? Where does the " boundary " between rail, road and coastwise traffic lie? Since some traffic will, in any case, go by rail, some by road and some by coastal steamer, what is the extent of the remaining traffic open to competition between them? Thus the relative level of rates in the three systems is involved.

6. What is the physical condition of the various ports—their natural advantages and limitations, equipment and lay out? What is their capitalisation, form and efficiency of management? What are their dues and charges?

These numerous and far-reaching questions involving important matters of principle, constitute a whole field of study, a programme of investigation. This book does not attempt to examine or elucidate all these problems: its aim is the more modest one of aiding the first few steps of such investigation by sorting out some of the chief facts on which further conclusions must be based.

Dredging in the Port of Southampton

Extensive Deepening Project Completed

Historic

THE PORT OF SOUTHAMPTON lies under a debt incurred in prehistoric times, when the old Solent River, with its banks gradually submerged, and nature shaped the present contours of Southampton Water, the arms of the Solent and the protecting barrier of the Isle of Wight. It is thought that he submergence was quite recent in geological time and occurred around 10,000 B.C.

The development of steam navigation in the middle of the 19th Century, and particularly the coming of the Atlantic liners, with their ever increasing draught, pointed unmistakably to Southampton Water, with its incomparable tidal and physical advantages, as an ideal terminal.

Southampton is set across the direction of the prevailing gales, and so escapes the rise of any heavy sea. The Port is blessed with double day tides, a long flood with an intermediate flood stand, 2½ hours high water slack, a short ebb, and not least important, a range of tide which, whilst useful, dispenses with locking systems.

The use of the Port dates back to prehistoric times and the natural endowments of the harbour have been appreciated in turn by Phœnicean, Celtic, Roman, Saxon, Norman and Elizabethan navigators and shipbuilders.

The Southampton Harbour Commissioners were in 1803 first empowered by Act of Parliament to control and improve the port, but steam navigation and steel hulls were as yet unknown and the deepening of the natural sea channels was not demanded.

Previous Dredging Schemes

In 1882 the development of steam navigation led to the granting of powers to the Southampton Harbour Board by Act of Parliament to deepen the approach channels, and the Netley Shoal and Test bar were dredged to 26 feet at Mean Low Water Springs (M.L.W.S.) in 1889, to give that depth from Fawley to the Docks. Natural depths below Fawley were then ample.

In 1893 the Board increased the depth in these important reaches to 30 feet and in 1907, when Southampton became the European terminal of large liners, including such famous ships as the Oceanic, Majestic, Teutonic and Adriatic, a start was made to deepen the entire approach to 32 feet M.L.W.S., for the first time dealing with the approach below Calshot. The keels of the Olympic and Titanic were laid in 1909, the year when this dredging was completed and further deepening was planned.

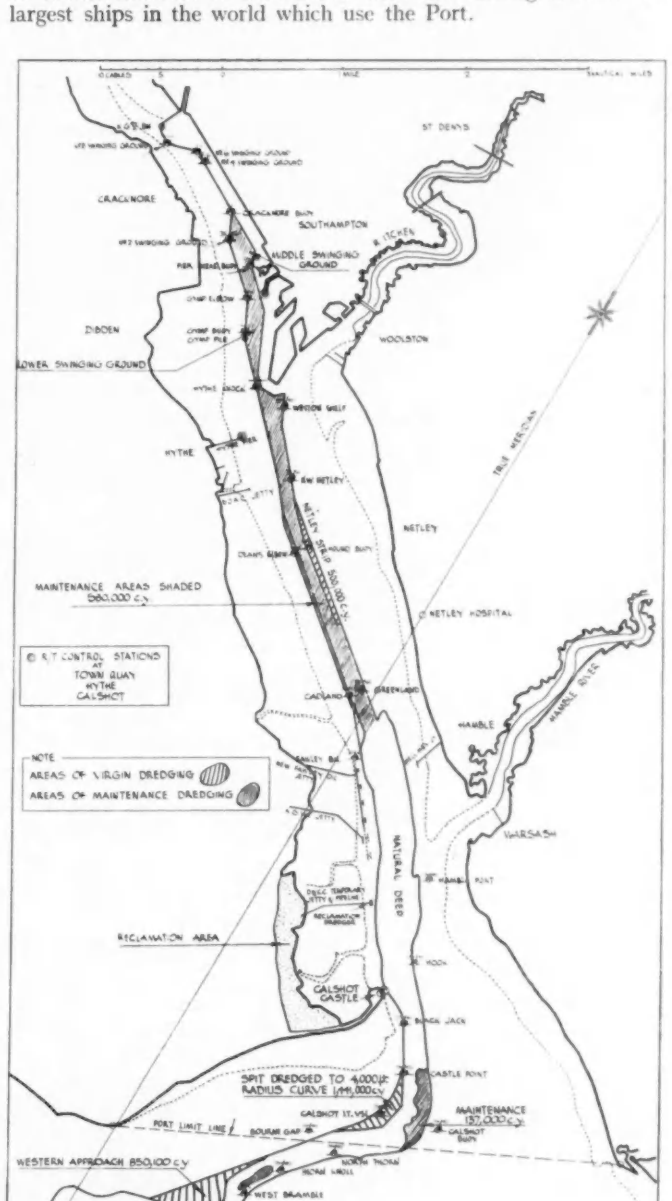
The liners Aquitania, Mauretania and Berengaria followed in due course, the latter drawing 38 feet, and between 1922 and 1927 maintenance and continuous operations for widening and deepening were demanded, not only in the reaches above Fawley up to the Docks and off the Docks, but also in the natural channel below Calshot down to the south western extremity of the Brambles shoal.

In 1931, the Southampton Harbour Board commenced the largest single dredging contract undertaken up to that date, involving the excavation of 2,750,000 cubic yards of material. The object of this work was to widen the channel where possible to 1,000 feet, to deepen the reaches below Calshot to 38 feet M.L.W.S. and to ensure a least governing depth in all the reaches above Calshot and up to the New Docks of 35 feet M.L.W.S. This project took five years to complete, and when the Queen Mary came off the stocks, Southampton was ready to receive her with her 39 feet load draught.

Present Dredging Scheme

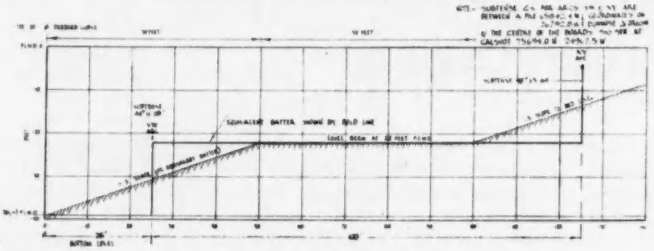
Prior to the second world war, the Board had under consideration schemes for further widening in the reach above Fawley and adjusting the Netley margin to tidal flow, but hostilities prevented the work being commenced.

In recent years, however, the Southampton Harbour Board has carefully re-examined the modern requirements of the Port and decided to execute major works for the rectification of the Docks to Fawley reaches, to give an 800 foot channel in line with tidal scour and also to rectify the Calshot Spit and Western Approach or Thorn Channel in accordance with the turning radii of the largest ships in the world which use the Port.



Plan showing major improvements by dredging in the navigable deep water channels in the approaches to Southampton.

Dredging in the Port of Southampton—continued



Calshot Spit. Plan showing berm and slopes required to westward of dredged curve set out on plan as specified. Final depths may be 1-ft. less than those shown.

Accordingly, in 1950, the Dredging and Contsruction Co. Ltd. of King's Lynn, was awarded a contract by the Southampton Harbour Board for major dredging works designed for the restoration and improvement of the main deep water sea channel in the approaches off the West Bramble light buoy and throughout the main channel inside the Port up to the Cracknore light buoy off the New Docks as illustrated on Plan No. 1.

The quantity of dredging in situ amounted to a little over 3,500,000 cubic yards, and comprised the following three principal items, each in itself a large project:

(i) **Western Approach:**

Dredging the Port Hand western margins of the Western Approach Channel off the West Bramble light buoy, and up to the Bourne Gap light buoy in a direction of 041°/221° (true) and to a least depth of 38 feet below Port Low Water Datum (P.L.W.D.). This bold widening of the entrance to this reach was designed to give greater freedom for ships in turning inwards, and particularly for the 1,000 feet liners using the Port, and was based on research involving the plotting of the tracks of the ships concerned when making this critical turn. It is understood that the benefit of this work has already been felt and favourably commented on by the Pilots and Commodores concerned. The quantity of material involved here was 850,000 cubic yards, and was composed of clay and gravel from areas where practically no siltation occurs, thanks to the dominant westerly streams of the Solent. It should here be mentioned that whilst above Calshot the maximum ebb tidal stream does not exceed a velocity of 2¼ knots the west going stream in the Western Approach may attain velocities at Springs of 3 knots.

In addition, with strong west south westerly winds, the longer windward " fetch " opened up along the axis of the West Solent allows a very confused sea to rise in this area. Due to both these circumstances, dredging here was the most difficult part of the Contract and it was found necessary to suspend work entirely from September, 1950, to April, 1951, in the Western Approach.

(ii) **Calshot Spit :**

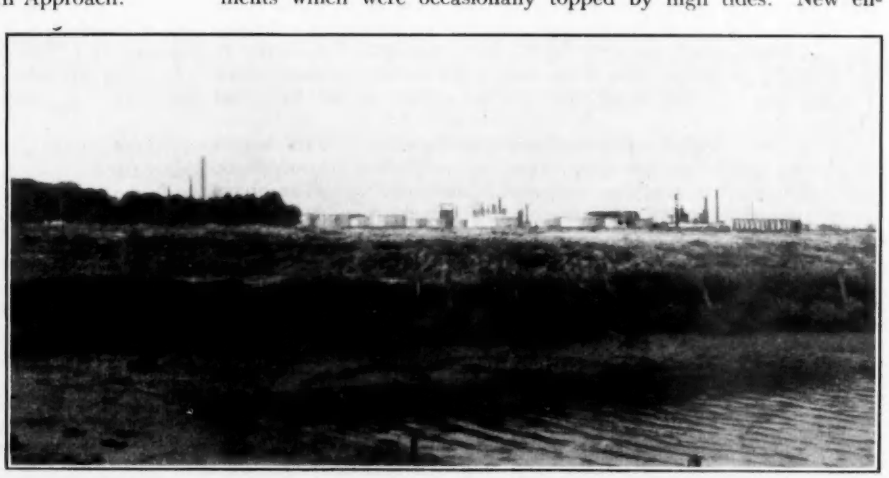
Dredging the easterly corner of the Calshot Spit to a 4,000 foot radius curve, joining up with the straight port hand approach dredged in the Western Approach channel, as shown on Plan No. 1, to give an easy turn for large ships with moderate helm and no requirement for engine assistance under normal circumstances. The quantity involved was just under 1,500,000 cubic yards. On this curve an intervening 50 foot terrace or " berm " has been cut between the 1 : 3 slopes required to ensure the under-water stability of this deep cut, where excavation from a depth of 8 feet down to 38 feet below Port Low Water Datum has been carried out (see Plan No. 2). The material here was composed of a mixture of clay and gravel. Here it may be remarked that the liners " Queen Mary " and " Queen Elizabeth " draw up to 40 feet and may, in shallow water, due to hydraulic factors, operating especially in a narrow channel with shoal margins, increase their draught by another 2 feet. The provision of sea channels for such extreme dimensions of length and draught in manœuvring is a requirement in this country which Southampton alone is obliged to meet. In addition to dredging the new Calshot curve to 38 feet below Port Low Water Datum (P.L.W.D.), some slightly shoal areas of the adjacent channel and Calshot Reach have been re-dredged where necessary to the same depth. Very little accretion has occurred in the main channel below Calshot since dredging in 1934. The greatest width of the channel off the Spit has now been increased from 1,650 to 2,500 feet.

(iii) **Reaches Upstream of Fawley :**

Between Calshot Castle and Fawley lies the Natural Deep, another bounty bestowed by nature, which has depths of well over 42 feet below P.L.W.D. Above Fawley Beacon and the new Esso Refinery lie those reaches of the Main Channel which have hitherto required constant dredging by the Southampton Harbour Board and extend up to a position off Cracknore off the New Docks. A drastic rectification of the Starboard Hand and easterly margins, lying between the N.W. Netley light buoy and shoal and the Cadland light buoy, has been made by dredging to a line 129°/309° (true) in alignment with dominant tidal ebb scour. This has moved the axis of the channel some 250 feet to the eastward and the eastern margin some 400 feet into a submerged terrain which, by its nature, is not so liable to siltation as the western margins which were composed of silt and mud from the soft swampy foreshores lying between Fawley and Hythe, interlaced with run-off creeks. The material dredged on this eastern Netley " strip " was composed of peat and timber from ancient prehistoric forests lying over clay and gravel, but dredging did not prove difficult. Some Roman pottery was dredged up during the course of these operations. Elsewhere in the reaches above Fawley, silt and accreted gravel and shingle predominated, with some greensand and a few concretinous boulders on the new margins abreast of the Hythe and B.O.A.C. jetties and in the Middle Swinging Ground immediately above the Royal Pier, off the New Docks. The quantity of material removed in the reaches above Fawley was just over one million cubic yards measured in situ, half of the quantity being dredged on the Netley " strip."

Reclamation Operations

An interesting feature of the Contract has been the disposal of large quantities of dredged material by pumping into reclamation areas ashore. The areas utilised for this purpose, as shown on Plan No. 1, were inadequately drained marshes, sited at the base of the hills on the west side of Southampton Water between Fawley and Calshot, originally laying at a level of about 6 feet below High Water and protected from tidal inundation by small embankments which were occasionally topped by high tides. New en-



Original sea bank in foreground, with heightened reclamation area near Fawley in background, filled to a depth of 10-ft.

Dredging in the Port of Southampton—continued

Reclamation Areas between Ashlett and Calshot with Reclamation Dredger pumping dredged material from barge through pipeline.

closure embankments were constructed by dragline excavators and were of sufficient strength to withstand the pressure of the material being pumped ashore inside the enclosures and of sufficient height to exclude the highest tides, the total area enclosed being approximately two hundred acres. A pipeline jetty consisting of timber piles and steel bridge spans was also constructed to convey the pipeline from the reclamation dredger (permanently moored at the seaward end of the jetty) on to the outmarsh in the vicinity of the Low Water Line; from whence the pipeline was laid across the outmarsh in to the enclosed reclamation areas, about 800 yards inshore from the Low Water Line. About 2,000,000 cubic yards of dredged material had been pumped into the reclamation areas when the Contract was completed, the remaining material having been dumped at sea in the authorised deposit areas off the Nab Tower and the Needles.

During the peak period, three large bucket dredgers, a reclamation dredger, ten self-propelled sea-going hoppers and seven dumb reclamation barges, with tugs and ancillary craft, and a total labour force of about 250 men, were employed on the project.

The time for completion of the work was estimated at twenty months, but the Contracting company succeeded in completing in about fourteen months, six months less than the contract time.

Navigational Aids

Following the completion of the dredging programme described above, the Southampton Harbour Board in consultation with Trinity House is now examining all the buoys, beacons and other navigational aids in the Port area. A considerable revision of buoyage is being planned to conform with the improved approaches and channels resulting from the dredging programme and where necessary new navigational aids will be provided by the Board.

A further subject now being investigated by the Board is the provision of a Port Control and Information Service. This will embody the use of radar and radio telephone facilities and the plan is to provide full information to shipping interests, to assist in the safe and speedy handling of vessels in the Port. Consultations have taken place between the Board and the Ministry of Transport, Post-Master General and a number of specialist firms in the radar and radio-telephone industry and it is hoped in the near future to complete the plans for this service.

With the completion of the dredging work and the improvement in navigational aids outlined above, the Board will have maintained its traditional policy of providing first-class port facilities not inferior to those of any other major port in the world.

New Barges for British Waterways.

Three barges of a new type are now being built for the Inland Waterways Executive by the Fairmile Construction Co., Ltd. They will have an increased cargo carrying capacity of between four and five tons resulting from the use of high tensile steel and welded joints in place of riveted mild steel construction. This has been achieved by the use of lighter scantlings and the reduction of the shell plating thickness of 1/16th inch. The cost has not been increased because the reduced weight of steel, used without loss of strength, offsets the higher price of the metal. It is estimated that threequarters of a ton of the total saving is due to employing welded instead of riveted construction. A further point of interest is that, at the request of the British Iron and Steel Federation, one of the three vessels will be plated in Cor-Ten. This is a low alloy high tensile structural steel containing 0.25 to 0.5 per cent. of copper, which is stated to have more than four times the atmospheric corrosion resistance of ordinary mild steel. The use of this material for plating will increase the cost of the barge by about £30. The new method of construction has been adopted experimentally on the proposal of the Executive's Research Department, which collaborated in preparing the designs.

Pre-Stressed Concrete for Structural Work

Its Application to Building Generally, and to the Gas Industry *

By S. V. GARDNER, M.I.Struct.E., A.M.I.C.E.
Designer Engineer (Reinforced Concrete), North Thames Gas Board

(Continued from page 229)

GANTRIES AND OPEN FRAMEWORKS

Many structures under this heading are designed using precast beams, columns and braces. In this field, pre-stressed concrete can be particularly useful, both in regard to its elasticity and ease of handling. Moreover, the pre-stressed concrete member is usually appreciably lighter than its reinforced concrete counterpart, hence transport and handling costs are proportionately reduced.

Examples of this type of structure carried out in pre-stressed concrete are available on the Beckton and Bromley Works of the North Thames Gas Board, and further projects are contemplated at both of these works.

The largest project at present almost completed is the provision of over 60 open-frame trestles for supporting large diameter gas mains and light steel gantries for steam, water and electricity services within the Works. These trestles vary in height between 20 and 35-ft., and are supported on two piles. The bases, caps and intermediate braces are cast *in situ*, while the legs are pre-stressed concrete members of taper section, varying from 10-in. x 12-in. at the top to 10-in. x 15-in. at the base. A deep pocket is provided in the base, into which these legs are dropped and anchored, this pocket also allowing for some final adjustment in the height of the trestle should such variation be found necessary. A typical example of these trestles is shown in Fig. 11.

Fig. 11. Open-frame Trestles.

Before accepting the tapered trestle legs on the site, a loading test was again specified. As the most severe loading imposed on these units would probably occur during their handling, transportation, and fixing, in very much the same way as for a pre-cast pile, a bending test was chosen.

The test specimen was supported at 30-ft. centres and subjected to equal loads applied at the third points, the deflection at the centre being measured at each increment of load.

The unit was tested by the application of upward loads from 20-ton jacks placed at the load points, the actual dead-weight of the unit and end shackles being deduced from the loads recorded by the pressure gauge.

Table 1 presents the results of this test, together with the calculated bending moments and approximate stresses induced at the opening left for the *in-situ* brace near the centre of the member.

Further projects are in hand, at both the above Works, for the provision of coal and coke gantries. These structures will consist of trestles approximately 50-ft. high, spaced at 60-ft. centres, between which span twin pre-stressed beams of tee-section carrying a central shuttle conveyor. These beams will be constructed on the Hoyer bonded wire method and transported to the site and hoisted into position.

FRAMED BUILDINGS AND STRUCTURES

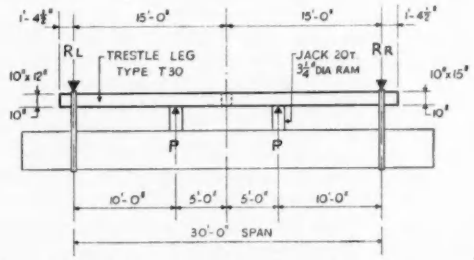
Many opportunities occur in this type of work in which pre-stressed units may be used with advantage, and there are numerous examples, throughout the country, of single and multi-storey structures carried out at least partially in pre-stressed concrete.

In many cases, normal reinforced concrete columns are installed, using pre-stressed beams and slab units, although in some cases the columns also have been pre-stressed, particularly where these are subjected to high wind moments.

An example of such a project is the factory at Newport, Monmouthshire, constructed as an extension to the works of South Wales Board Mills, Limited. Illustrations of this project are given in Figs. 12 and 13, where the assembly of the precast concrete column units, preparatory to post-tensioning by means of Freyssinet jacks, is clearly shown.

TABLE I

Pressure Gauge (lb. per sq. in.)	Equivalent Load (lb.)	Deflectometer Reading (in.)	Deflection (in.)	Nett Load (lb.)	Bending Moment (max.) (lb. in.)	Stress at Opening (lb. per sq. in.)	Pre-stress at Opening (lb. per sq. in.)
1	2	3	4	5	6	7	8
290	2,280	+0·982	0·00	0	0	0	1,420
300	2,360	+0·960	0·022	80	9,600	55	1,420
350	2,750	+0·949	0·033	470	56,400	322	1,420
400	3,140	+0·865	0·117	860	103,200	590	1,420
450	3,540	+0·710	0·272	1,260	151,200	865	1,420
500	3,930	+0·543	0·439	1,650	198,000	1,130	1,420
550	4,330	+0·400	0·582	2,050	246,000	1,405	1,420
610	4,800	+0·218	0·664	2,520	302,400	1,728	1,420
660	5,190	+0·075	0·807	2,910	349,200	2,000	1,420
690	5,430	−0·003	0·985	3,150	378,000	2,160	1,420
705	5,540	−0·036	1·028	3,260	391,200	2,235	1,420
750	5,890	−0·158	1·140	3,610	432,200	2,462	1,420
810	6,370	−0·348	1·330	4,090	490,800	2,850	1,420
615	4,840	+0·286	0·696	2,560	307,200	1,752	1,420
520	4,080	+0·395	0·587	1,800	216,000	1,230	1,420
350	2,750	+0·894	0·088	470	56,400	322	1,420



Where pre-stressed slabs are used, these may take the form of sectional precast floor units comparable with the many types of conventional precast flooring schemes so familiar to-day.

On the other hand, the units may contain the whole of the main tensile reinforcement, and yet be laid as thin slabs 2 or 3-in. thick over which a final *in-situ* slab is cast, uniting the whole of the precast units into one " monolithic " structure. Such a structure has been built at the Nine Elms Works of the North Thames Gas Board, where a new charging floor has recently been constructed within an existing retort house. In this case the supporting columns and beams were carried out in normal reinforced concrete work. Thin, pre-stressed concrete permanent shuttering slabs were placed between the beams, and a 5-in. thick *in-situ* concrete topping was added to unite the whole structure. The pre-stressed units contained the whole of the main tension reinforcement for the floor slab, the only extra reinforcement required for the slab being longitudinal distribution mesh reinforcement laid in the

*Reprinted from Communication No. 376 of The Institution of Gas Engineers by courtesy of the Council. Copies of the full work are obtainable from the Secretary of the Institution, 17, Grosvenor Crescent, London, S.W.1, at a cost of 2s. 6d. per copy, post free.

Pre-Stressed Concrete for Structural Work—continued

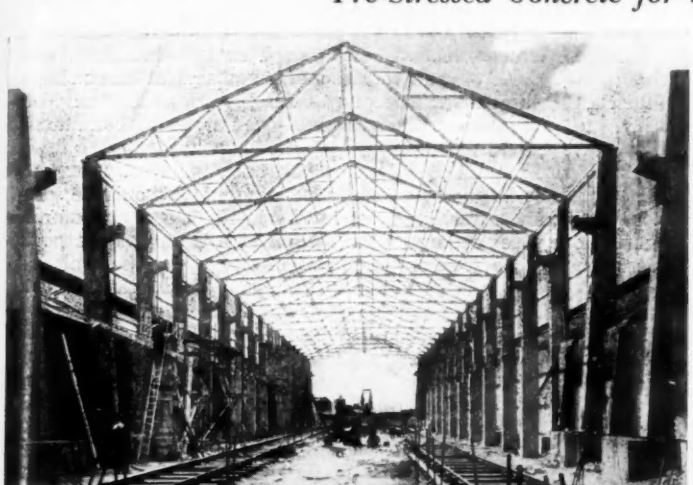


Fig. 12. A Newport (Mon.) Factory Extension, showing Pre-stressed Columns.

topping. It was not considered wise to use pre-stressed beams in this project, owing to the high temperatures in the vicinity of the retort bench, not because pre-stressed concrete has a particular weakness in this direction, but rather, that insufficient information was available at the time concerning the effect of heat on pre-stressed concrete. Further investigations in this matter are contemplated in the near future. A similar form of construction using thin pre-stressed concrete slabs could equally well be used for the construction of walls, eliminating the need for timber shuttering, which at the present time is extremely expensive.

TANKS AND SIMILAR STRUCTURES

Structures subjected to internal hydrostatic pressure, combined with variations in temperature, are prone to crack under the action of the forces involved, unless the working stresses are kept very low in order that the concrete should not fail in tension.

The introduction of a pre-compression into the walls of tanks will tend to eliminate any tendency for cracks to form. This is particularly useful in tanks partly filled with hot liquids, in which the lower parts tend to expand more than the freeboard sections, resulting in the formation of cracks above the water line. It is considered that the pre-stressing of such tanks could effectively and economically be carried out, although it would have to be done in two directions mutually perpendicular.

Circular tanks, where the walls are subjected almost entirely to circumferential tension forces, can be effectively pre-tensioned by winding bands of high tension wire around a plain concrete or lightly reinforced concrete ring. The wires may be automatically tensioned by the winding process, or, alternatively, turnbuckles may be used, provided proper care and attention be given to the question of friction between the tensioned rod and the concrete ring, to ensure an even distribution of the pre-stress.

This process is eminently suitable for use in the construction of large diameter gasholder tanks where it is thought very considerable saving in concrete could be made. Many such structures erected above ground level are little difference from large diameter water storage tanks, of which several examples exist in pre-stressed concrete construction.

CIVIL DEFENCE

While the engineer, as much as any other British citizen, is anxious to avert such a catastrophe as war, he must nevertheless be prepared for all eventualities.

During the last war, stocks of standard pre-stressed beams were held by some railway companies to provide quick repair units for damaged bridges. These units are admirably suitable for handling and movement by inexperienced labour under difficult conditions, being lighter and more elastic than their equivalent in reinforced concrete. The use of steel, which during a war would be strictly limited, is cut down to the very minimum in these units.

Each engineer knows best the needs of his own works, but the following suggestions may be of interest:

(1) Light pre-stressed concrete slabs to cover holes made in floors or roof slabs.
(2) Short columns (say, 4-in. x 4-in. or 6-in. x 6-in. in cross-section) to underpin structures at close centres in the event of damage to the main supports near ground level.
(3) Pre-stressed concrete shores, which may be used on a mass concrete base to support the heavy brickwork of an old retort house or other building, loosened or rendered dangerous by blast.
(4) Pre-stressed concrete sectional units for assembling on the site to form small hoppers, tanks, control cabins for essential workers, or screens to protect vulnerable plant.
(5) Light A-frames for spacing at close centres to support overhead cables, steam mains, water services and possibly gas mains.
(6) The careful design of present Works, eliminating points of obvious weakness, and the full utilization at least of the lessons learnt in the past war in respect of structural failures.

In each of the above proposals it is, of course, of paramount importance that the units provided should be as light as possible so that they may be handled by a small number of men without mechanical aid other than perhaps a small trolley for transporting the units across the Works, and block and tackle for hoisting purposes.

It is quite impossible, of course, to set out any standards of design, and one must look to higher technical authorities for guidance should the necessity arise.

SPECIAL APPLICATIONS

Examples of numerous specialized applications are available. Amongst the more interesting subjects are the following:

(1) Structures of annular cross-sections, such as pressure pipes, ducts and tunnels. (See "J. Inst. Struct. Eng.," March, 1945.)
(2) Cofferdams and caissons. (See French publication on "The Variety of Applications of Pre-stressed Concrete," by M. Lalande.)
(3) Machine frameworks. (See notes on "Hydraulic Presses," by E. Freyssinet in his paper, "Pre-stressed Concrete: Principles and Applications," to The Institution of Civil Engineers, 17th November, 1949.)
(4) Sundry repair and reconstruction works, including underpinning.

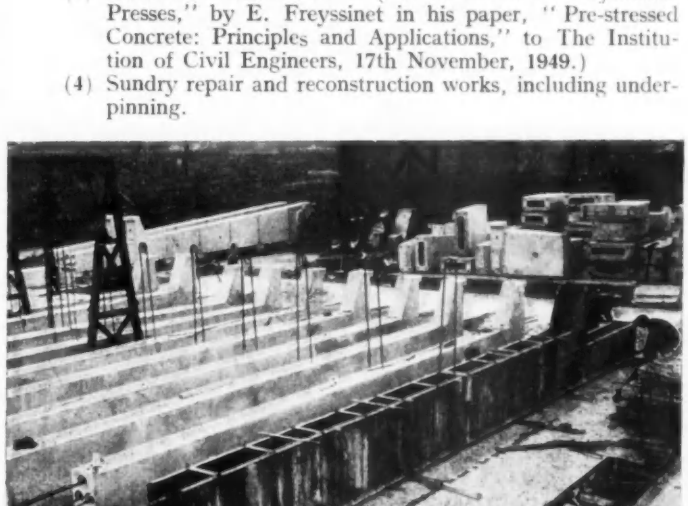


Fig. 13. Sectional Column Units before Pre-stressing.

Pre-Stressed Concrete for Structural Work—continued

The above constitute a selection from the many examples encountered that may, in due course, prove of special interest. Pressure pipes described by the late Dr. Mautner under the above reference were tested to failure. The specimen used had an internal diameter of 800 mm. (31.5-in.) and withstood an internal hydraulic pressure of 330 lb. per sq. in. before the first signs of water appeared on the outer face.

The pipes were manufactured by winding with a controlled-tension high-tensile wire reinforcement around the perimeter of a spun concrete pipe, the wires being finally covered by concrete from a cement gun.

With regard to the pre-stressing of tunnels, such a project is now being contemplated for the conveyor tunnel associated with the proposed coal gantry, at Beckton Gas Works, to which previous reference has been made.

The tunnel will be composed of short precast box sections, through the four corners of which will be threaded high-tensile wire cables post-tensioned by the Freyssinet method when all the units have been placed in position and properly aligned.

The foregoing survey is not intended to be exhaustive, but rather a brief outline of the possibilities of the use of pre-stressed concrete with the Gas Industry. Many engineers are well informed on the subject, whilst others may have hesitated to venture into a rather new and controversial field of structural development. As previously stated, however, it is essential that all engineers be fully alive to developments in their particular field, and to be prepared to study their merits and claims in detail, so that they may be able to substantiate their reasons either for adopting or refusing to consider such new processes.

CONCLUSIONS

It is confidently believed that the underlying principles and advantages claimed are of considerable value to the gas engineer, whose structures are, perhaps, subjected to more severe conditions than are usually met elsewhere.

A number of important points should be noted, however, in the execution of pre-stressed concrete works, these being summarized below:

(1) Pre-stressing is most efficient when the working stresses in concrete and steel are as high as possible.
(2) To comply with the above, the use of high-grade materials, particularly properly graded and compacted and cured concrete, is essential.
(3) Steel fixing must be more accurate than is accepted in normal reinforced concrete practice, owing to the very high stresses used.
(4) Pre-stressing should only be done by properly trained and experienced men.
(5) All materials should be properly tested before use and periodically during the course of the work.
(6) The estimation of the pre-stress induced in the wires must be checked accurately by measuring the elongation of the reinforcement and comparing with the calibrated pressure gauge on the jack,or some other reliable process such as the acoustic method.
(7) Design should be carefully prepared on a pre-stressed concrete basis, and not on a reinforced concrete basis and subsequently adapted.
(8) Proper attention must be given to the end anchorage and the heavy stresses induced by the tension forces in the case of the post-tensioning method.
(9) Cables designed for post-tensioning must be properly and completely grouted to prevent corrosion within the duct.
(10) It is advisable to maintain the greater covers of concrete usually adopted for Gas Works structures, when using pre-stressed concrete.

If the above points are given due consideration. it is believed that, in most cases, a structure 10 to 30 per cent. cheaper and lighter wil be produced by an experienced engineer.

Once again, however, the engineer who, no doubt, already has as much work in hand as he can deal with, is called upon to start studying again, this time the subject of pre-stressed concrete. The theories involved can be complex, since the work is not confined to simple span beams, but extends to continuous structures and frames, circular sections pre-stressed in two directions, and the analysis of the stresses in structural members at three stages in their life, i.e., at the release of pre-stress; in use under dead load conditions; and in use under full dead- and live-load conditions. Many other more involved problems are available for those willing to consider them, and the engineer will, once again, be reminded of the fact that he has never really left school. It would be, perhaps, opportune to remind those interested that series of lectures, covering one week's duration and dealing with the main aspects of pre-stressed concrete, are held periodically by the Cement and Concrete Association for those intending to study the subject. Attendance at one of these courses would, no doubt, give the required start and enable subsequent study and investigation to be carried out more easily.

In conclusion, it is hoped that the British engineer, whilst not being able to claim originality, may however, be quick to appreciate the merits of this fascinating subject and demonstrate to fellow engineers throughout the world, in no unmistakable way, the reliability and sound workmanship so characteristic of all that he undertakes.

Acknowledgment is due to Dr. J. Burns, G.M., Chief Engineer, North Thames Gas Board, for permission to describe the works carried out by the Board, and also for the use of photographic illustrations in the text depicting these works.

Acknowledgments are also due to the following for permission to illustrate their processes and to include illustrations of their contract works:

(a) Concrete Development Company, Limited; (b) Stressed Concrete Designs, Limited; (c) Structural and Mechanical Development Engineers, Limited ; (d) Preload (Great Britain), Limited; (e) Rendel, Palmer and Tritton, Consulting Engineers, and Dow Mac (Products), Limited; (f) North Thames Gas Board, and (g) The Cement and Concrete Association.

Correspondence

To the Editor of *The Dock and Harbour Authority*.

Dear Sir,

Education Scheme for Port Workers

I have read with much interest the article in the November issue of " The Dock and Harbour Authority " on Port Organisation and Finance by a Special Correspondent.

May I, however, draw your attention to two points in the article.

Your Correspondent refers to the first " Trust " Port Authority as appearing in 1858. The Belfast Harbour Commissioners, however, were constituted a Port Authority by Act of Parliament in 1847, so that they would appear to be the first Trust Authority.

With regard to the constitution of the Belfast Harbour Commissioners, I would point out that the Chairman of the Board is elected by the Commissioners from amongst their number. He is not the Minister of Commerce, who is not a member of the Board.

The Board consists of twenty-one Commissioners (not nineteen, as stated by your Correspondent) with the Lord Mayor of Belfast as an *ex-officio* member.

The present Chairman of Messrs. Harland & Wolff, Ltd., is a member of the Board but he holds office not as the representative of his Firm, but as a member duly elected by the ratepayers, in the same way as the other Commissioners are elected.

Yours faithfully,

JAMES ALEXANDER.
C.B.E., M.Inst.T.
General Manager and Secretary.

Harbour Office,
Belfast.
9th November, 1951.

New Port for Madagascar.

It was recently announced in the French Press that a new port is to be built at Avaradrova, in Madagascar, at a cost of 320 million francs. The port will cover 30,000 square metres, and the work is expected to take about three years to complete. The piles and piers will be constructed in pre-stressed concrete, a method of construction being used for the first time in Madagascar.

Model Investigations of Aberdeen Harbour*

By J. D. LAWSON

A scheme of development for the Port of Aberdeen was outlined in an interim report by their Engineer, Mr. John Anderson, M.I.C.E., to the Harbour Commissioners in 1943 (*The Dock and Harbour Authority*, July and August, 1945). Among other features, the scheme provides for possible extensions to the existing North Pier and South Breakwater. Although the existing structures are remarkably effective having regard to the very exposed position of the Harbour, there is nevertheless under certain conditions an undesirable "range" of water movement within the Harbour, especially in the Albert Basin or Fish Dock. The purpose of the scale-model experiments is to study the probable behaviour of the various proposals and the mechanism of sand deposition in the navigable channel, where dredging is necessary. One problem which deserves consideration is the possible secondary effects of any new breakwaters and dock entrances upon currents and accretion or scour of the bed.

Fig. 1 indicates the area embraced by the model which has been designed and built in the Engineering Department at Marischal College, University of Aberdeen, under the direction of Professor Jack Allen. A portion of the tidal stretch of the River Dee has been bent round into a more compact space; observations of tides and currents within the area concerned in the investigation confirm that this convenient device has no deleterious effect. Tides are generated by a counterbalanced steel plunger carrying water ballast, in a manner closely resembling that previously employed on models of the Severn, Liverpool Bay, Cheshire Dee and Tay estuaries. This method, including the epicyclic train of gears for varying the stroke of the plunger so as to simulate an average lunar cycle of tides, has been fully described elsewhere.† The river flow of the Dee can be supplied either from an overhead tank or by pumping from the seaward end of the model. It is regulated by adjusting the head over one of a selection of calibrated orifices.

Surface, or storm, waves are generated by the to-and-fro movement of an aluminium paddle 13-ft. long by 2-ft. deep hinged at its two lower corners (see Fig. 2). The stroke of this paddle can be varied at will by means of an eccentric and the frequency can be altered over a wide range with the aid of an "infinitely-variable" gear. It is proposed to alter the direction of wave propagation by (a) guide baffles and (b) changing the position of the paddle. In the first place, waves are being generated from approximately due east.

The horizontal scale of the model is 1 : 660 (8-ft. = 1 mile) and the vertical scale 1 : 60 (1-in. = 5-ft.) so there is a vertical exaggeration or distortion of 11 : 1. The velocity scale is 1 : $\sqrt{60}$ or 1 : 7.75, and a tidal period of 12.4 hours is represented in the model by 8·73 minutes. While it is generally agreed that some distortion of the vertical scale is desirable and, indeed, essential in a tidal model, at the same time, an undistorted scale is regarded as appropriate when surface waves and their propagation in harbours and on beaches is the predominant phenomenon under investigation. Distortion of the vertical scale may mean that those waves of which the energy is dissipated on an actual beach are reflected on the steeper slopes in the model structure. Accordingly, it is realised that the present model of Aberdeen Harbour may not yield sufficiently precise results for final conclusions to be drawn on all questions addressed to it. It is believed, however, that valuable guidance will be provided as to the relative merits of proposed developments and that if, later, a larger model proves to be necessary, the time and labour spent on it will be greatly reduced; moreover, experience with the present model will be useful in the design of any more elaborate type — for example, it will be known whether sufficient area of the North Sea has been included. It is also proposed to alter the vertical scale of the existing model subsequently so as to give a vertical distortion of 7 : 1 and finally 3 : 1, in the hope that scale-effects may be detected and some allowance made for them if necessary. With each vertical scale, waves of different directions and frequencies will be tried. If the time scale for such waves is interpreted in relation only to the

Fig. 1.

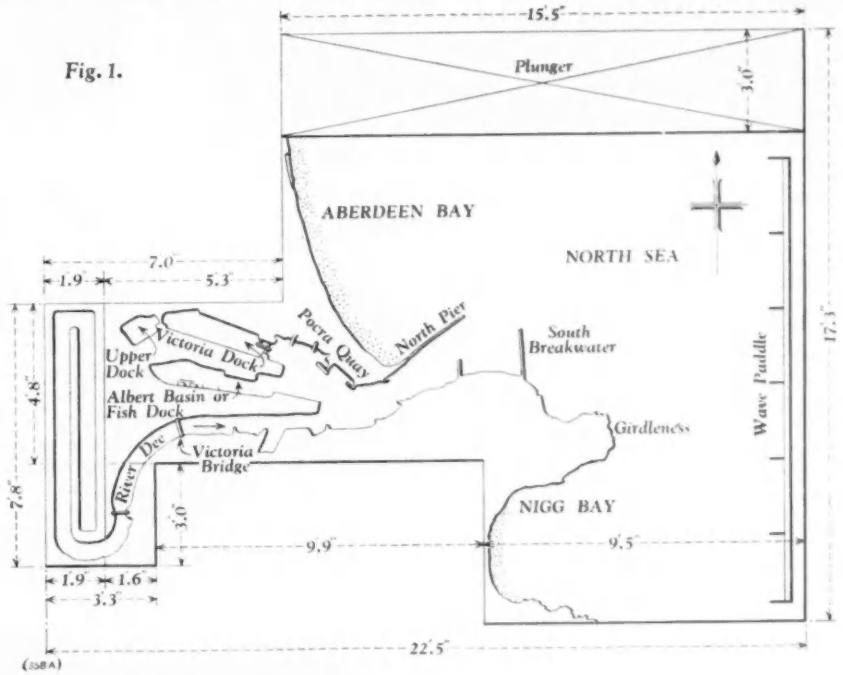
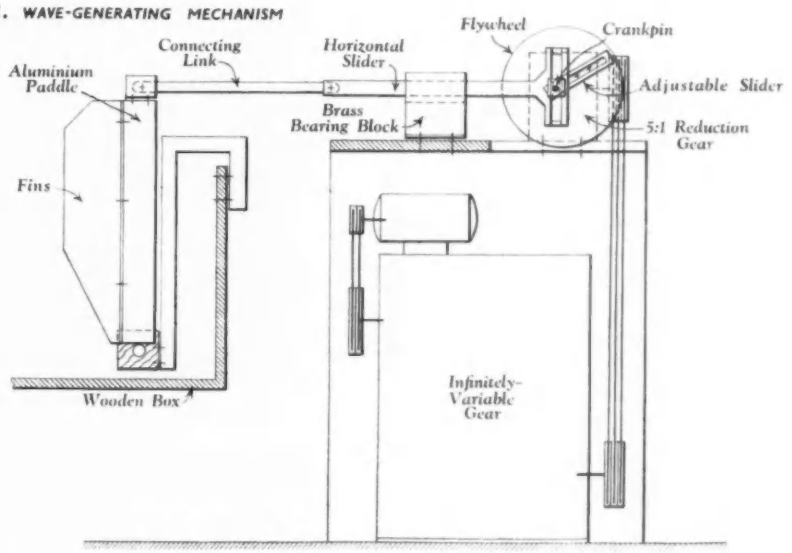


Fig. 2. WAVE-GENERATING MECHANISM



*Paper read before Section G of the British Association at Edinburgh on Tuesday, August 14, 1951. Abridged.

†"Scale Models in Hydraulic Engineering," J. Allen. Longmans, 1947, Chapter IX.

Model Investigations of Aberdeen Harbour—continued

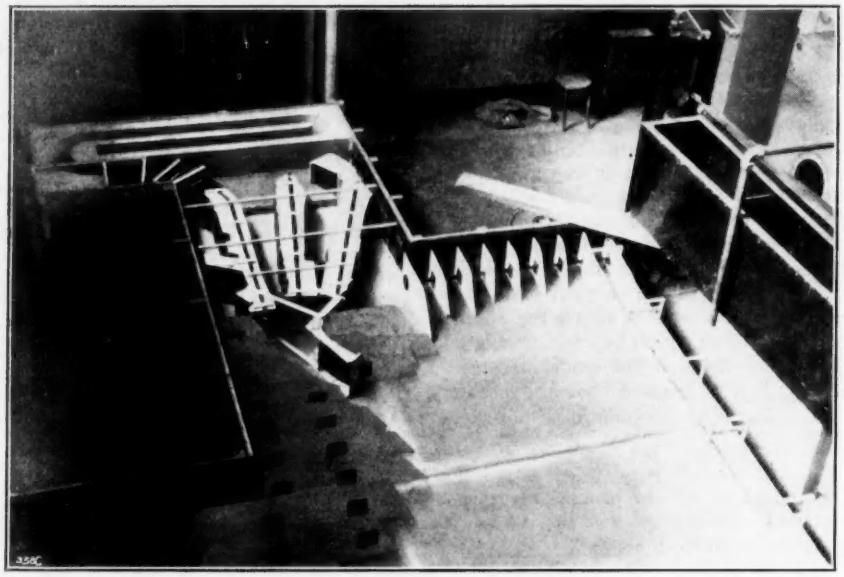


Fig. 3. Model under construction.

present vertical scale, it becomes $1 : \sqrt{60}$, or $1:\frac{\sqrt{60}}{660}$, or 1:7·75, as compared with 1:85·2 for the tidal period. In terms of the horizontal scale of 1 : 660 and vertical scale of 1 : 60, the following data are applicable :

(i) River discharge of the Dee (catchment area down to Aberdeen 816 sq. miles) —(a) average (based on river-gaugings at Woodend over a period October 1, 1929, to September 30, 1944, together with an estimate for the 288 sq. miles between Woodend and Aberdeen)—1,500 cusecs in Nature, represented by $\frac{1500}{660 \times 60^{\frac{3}{2}}}$, or 0·005 cusecs in the model; (b) peak (based on river-gaugings at Woodend—January, 1937)—44,000 cusecs, or 0·14 cusec in the model.

(ii) Tidal range at Aberdeen — ordinary springs—12·75-ft. in Nature, 2·55-in. in the model.

(iii) Wave height of, say, 15-ft. in the North Sea—3-in. in the model.

(iv) Wave range of, say, 2-ft. in the Inner Harbour—0·4-in. in the model.

(v) Current-velocity of 1 knot in Nature $\frac{1 \cdot 69}{7 \cdot 75}$, or 0·218-ft. per second in the model.

The model has been constructed in a waterproofed wooden box; exposed land masses were cast in 5 : 1 cement mortar; the bed has been moulded up to H.W.O.S.T. in sand passing a No. 10 sieve for the preliminary tide, surface current and wave observations; in some places the vertically exaggerated underwater banks have been stabilised with a coat of neat cement paint. At present, therefore, the whole bed is virtually fixed to preserve a constant configuration during observations of water movements. The photograph reproduced in Fig. 3 indicates the templates and collapsible "formwork" used in casting the sections of the Harbour in cement-sand mortar. Fig. 4 is a photograph (reproduced by courtesy of Aberdeen Journals, Limited) of the model taken after construction and during trial tests on the wave generator.

Preliminary experiments have been confined so far first to tides. The rate of rise and fall in the model, as compared with that in Nature, for ordinary spring and neap tides is shown in Fig. 5. The effect of the River Dee flow on the tidal range at the various gauges has been investigated — for example, with ordinary spring tide conditions, a river flow of 30,000 cusecs (large flood flow), and tidal range at the end of the South Breakwater of 13·1-ft. in the inner harbour at Pocra Quay the range is 12·3-ft. and at Victoria Bridge (about a half mile farther up the river Dee) it is 9·1-ft. Further, it is found in the model studies that, up to a certain discharge, the low-water level in the Pocra Quay basin is lowered with increased River Dee flow (see Table 1). This phenomenon is accounted for by the fact that the high-velocity river flow at low-water exerts a "drag" on the water in the basin; at higher discharges the effects of turbulence, channel shape and roughness counteract this "drag" effect and the level then rises.

Current movements in the model harbour have been observed and measured by (1) plotting the course of cork surface floats ; (2) photographing illuminated surface floats; and (3) plotting the course of immiscible droplets. Methods 1 and 2 have been used for surface currents and method 3 for subsurface movements. By method 1, the passage of an equivalent 5-ft. immersed cork float is plotted with reference to a 1-ft.

TABLE I

River Dee Flow—Cusecs,	0	2,000	5,000	10,000	20,000	30,000
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
L.W.O.S.T. at Pocra Quay	9 3	9 2¾	9 2	9 1¾	9 0	9 10½

square grid of cords supported in a horizontal plane 5-in. above H.W.O.S.T. Weighted pointers, hung from the cords, indicate the course taken by the float, while by timing the float between pointers the current speeds for the various sections of the channel are made known. A similar grid marked on plans of the harbour area facilitates transference of the float courses from model to paper. In method 2, a hollow Duralumin cylinder filled with paraffin and provided with a lid and small wick is loaded to give an equivalent 5-ft. immersion. With dark conditions in the laboratory, the movement of this lighted float is photographed from a position almost vertically above the model harbour. Several such

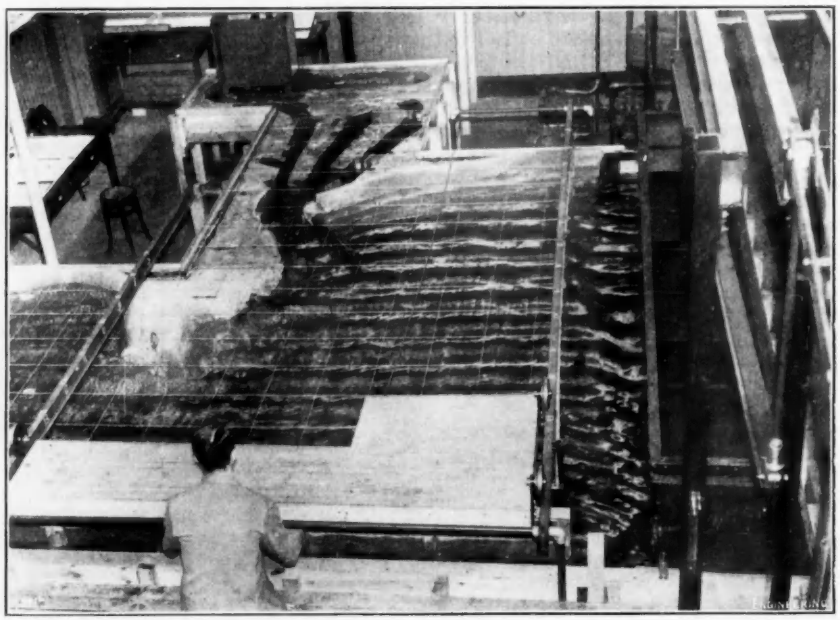
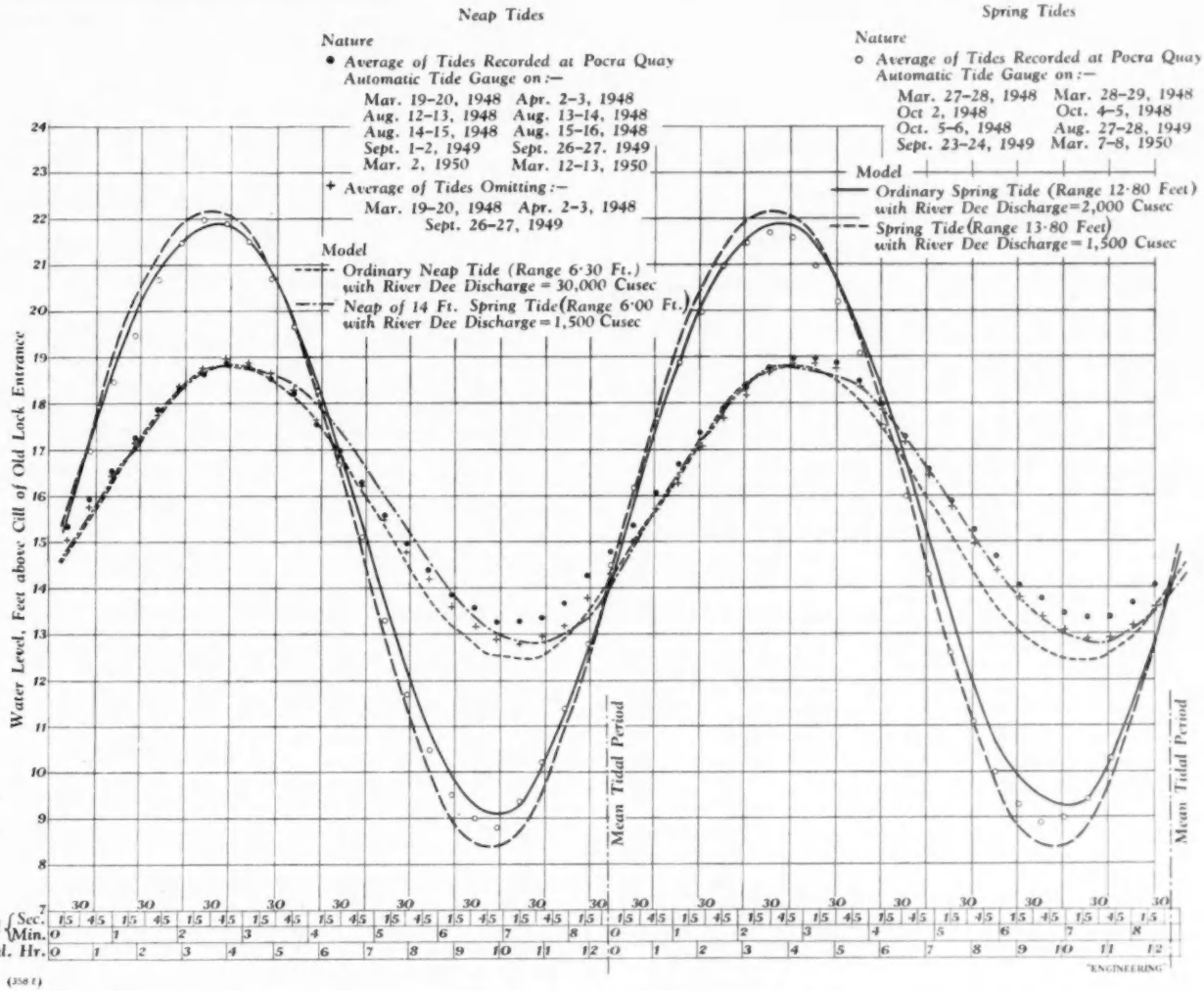


Fig. 4. Trial Tests of Wave Generator.

Model Investigations of Aberdeen Harbour—continued

Fig. 5. POCRA QUAY, ABERDEEN HARBOUR


Neap Tides
Nature
• Average of Tides Recorded at Pocra Quay Automatic Tide Gauge on:—
Mar. 19–20, 1948 Apr. 2–3, 1948
Aug. 12–13, 1948 Aug. 13–14, 1948
Aug. 14–15, 1948 Aug. 15–16, 1948
Sept. 1–2, 1949 Sept. 26–27. 1949
Mar. 2, 1950 Mar. 12–13, 1950
+ Average of Tides Omitting:—
Mar. 19–20, 1948 Apr. 2–3, 1948
Sept. 26–27, 1949
Model
Ordinary Neap Tide (Range 6·30 Ft.) with River Dee Discharge = 30,000 Cusec
Neap of 14 Ft. Spring Tide (Range 6·00 Ft.) with River Dee Discharge = 1,500 Cusec
Spring Tides
Nature
o Average of Tides Recorded at Pocra Quay Automatic Tide Gauge on:—
Mar. 27–28, 1948 Mar. 28–29, 1948
Oct 2, 1948 Oct. 4–5, 1948
Oct. 5–6, 1948 Aug. 27–28, 1949
Sept. 23–24, 1949 Mar. 7–8, 1950
Model
Ordinary Spring Tide (Range 12·80 Feet) with River Dee Discharge=2,000 Cusec
Spring Tide (Range 13·80 Feet) with River Dee Discharge = 1,500 Cusec
Water Level, Feet above Cill of Old Lock Entrance
Mean Tidal Period
Mean Tidal Period
Model Sec.
Min.
Actual. Hr.
"ENGINEERING"

courses may be plotted on the same photographic plate followed by an exposure of the model with the electric lights on. It is possible to open the camera shutter for known periods of time so that any one float course may be divided into several sections (shown as a broken line in the photograph). The current speeds for the several sections are calculated by measuring the length of these lines on an enlarged projection of the photograph.

A comparison between methods 1 and 2 for surface current movements observed at half ebb of an ordinary spring tide with River Dee flow of 20,000 cusecs is given in Table II. Part of the discrepancy between the two sets may be due to the floats not having precisely the same depth of immersion; also it should be appreciated that velocities vary appreciably across the width of the channel.

A comprehensive set of observations taken

TABLE II Float Velocity in Knots

	River Section	Entrance Channel	Victoria Bridge to S. Breakwater
Cork float	2.74	1.16	1.74
Lighted float	3.14	1.30	1 83

in Nature in the entrance channel revealed a marked "two-layer flow" phenomenon for that particular set of tide and river conditions. Analysis of water samples showed a large density variation over the depth, accounting for the outward flowing fresh river water on top and the denser tidal water being propagated into the harbour near the bed of the channel. In an attempt to reproduce this effect in the model, ordinary "fish-curing salt" was added to the body of water in the model until sea-water density was attained and the river water was supplied from fresh-water tanks instead of by circulation through a centrifugal pump. The subsurface current movements were observed (method 3) by injecting, at any equivalent depth, a mixture of carbon tetrachloride and benzine coloured with Waxoline Victoria Blue B.S. dye. This mixture, proportioned to be of the same density as the water in the model, forms red droplets which are immiscible with water. The movement of droplets injected at known equivalent depths showed conclusively the "two-layer flow" phenomenon. In fact, by injecting a series of droplets over the depth, the position of change-over from outward-flowing to inward-flowing water was quite distinguishable. The velocity/depth pattern observed in the model was similar to that in Nature, though, in general the model velocities were smaller. It is of interest to remark on the quantity of salt required to maintain the correct density conditions. Assuming the river flow is fresh water and the compensating discharge is sea water and the River Dee flow is 5,000 cusecs,

the fresh water added per hour $= \frac{5{,}000}{307{,}000} \times 3{,}600 = 58{\cdot}5$ cu. ft.; the salt added per hour $= 1{\cdot}6 \times 58{\cdot}5 = 93{\cdot}5$ lb. approximately, and the cost at, say, one penny per lb. = 8 shillings approximately.

At the time of writing, tests are in progress on wave reproduction in the model, and a series of observations has been taken for a range of paddle frequencies and strokes, using fixed tidal levels of H.W.O.S.T., L.W.O.S.T. and half-flood or half-ebb level. At one particular frequency of paddle oscillation the "wave surge," as recorded on the Fish Dock gauge, reaches a peak value due to resonance within the

(continued at foot of following page)

Marine Borer Research

Some Results of Studies in the U.S.A.

By GEORGE W. GRUPP

Marine borers are delicate of body but all of them are tremendously energetic in their business of destroying timber marine structures. They cut with microscopic fineness, and they work with such energy and speed, that they destroy millions of dollars worth of marine structures each year.

Of course faulty construction methods sometimes stimulate the destructiveness of marine borers. These methods range from the selection of unsuitable timber to improper treatment of the wood. Timber which is treated for only 5 or 6 hours is not as satisfactory as that which has been treated for 24 to 30 hours. Worthless preservatives are even less effective against borers than untreated wood, because these compounds lubricate the wood and make it easier for the marine borers to carry on their business of destruction. The maximum effectiveness of properly treated timber is reduced when workmen cut into the treated wood to attach untreated bracing timber. This makes it easy for the larvæ to enter the non-poisonous wood. From then on, the adult does not have much difficulty in penetrating the reduced treated portion of the timber.

Intensity of Marine Borer Attack in and near Miami, Florida.
Number of borings in all experimental panels according to month and Species.

Month	Unidentified young burrows	Teredo sp. (mainly pedicellata	Bankia sp.	Martesia sp.	Limnoria sp.
December, 1948	0	666	507	160	153
January, 1949	20	2398	14	11	221
February, 1949	992	2107	14	3	327
March, 1949	666	2246	0	2	405
April, 1949	1932	3878	0	0	676
May, 1949	1244	1894	1	0	501
June, 1949	1817	6225	5	12	874
July, 1949	2778	3416	2	60	614
August, 1949	3157	5502	39	33	565
September, 1949	5585	6720	0	75	790
October, 1949	6250	11155	12	39	717
November, 1949	3826	7681	54	33	579

Source: Bureau of Yards and Docks, U.S. Navy.

The following is an example of the destructiveness of marine borers. Just before the outbreak of the second World War, the U.S. Navy decided to build two additional piers, one 60-ft. x 680-ft. and the other, 60-ft. x 1,144-ft., at its naval base at Guantanamo, Cuba. The original design specified conventional precast reinforced concrete piles with a reinforced concrete deck.

Before it was possible to begin the construction of the piers, the United States became a partner of Britain in the war against Germany and Japan. The navy was in urgent need of the piers to carry on its wartime duties in the Caribbean Sea, and as steel restrictions were ordered by the Government, it became impossible to build the piers according to the original specifications. As a result, the engineers of the U.S. Navy's Bureau of Yards and Docks, used timber piles 12-in. thick and 90-ft. long to support a composite timber and moderately reinforced concrete deck.

While these timber piers served their purpose during the war, in 1948 it became apparent that marine borers were attacking the piling at the waterline. These organisms became so energetic that by January 1950 the piles were reduced to diameters that were considered dangerous; in fact, many piles had been completely eaten through at the water line. As a result, the piers were declared unsafe and their reconstruction was undertaken.

Average monthly number of borings per experimental panel in waters in and near Miami, Florida, for the period extending from December, 1948 to November, 1949.

Species	Depth	Average Number of Borings
Young unidentified borings	Surface	603
	2	825
	3	699
	Bottom	1630
		3757
Teredo sp. (mainly pedicellata)	Surface	867
	2	1195
	3	1424
	Bottom	2325
		5811
Bankia sp.	Surface	12
	2	30
	3	16
	Bottom	13
		71
Martesia sp.	Surface	8
	2	9
	3	11
	Bottom	13
		41
Limnoria sp.	Surface	150
	2	297
	3	337
	Bottom	477
		1261

Source: Bureau of Yards and Docks, U.S. Navy.

Because of this, and other comparable experiences, the Office of Naval research, with funds supplied by the U.S. Navy's Bureau of Yards and Docks, engaged the Marine Laboratory of the University of Miami to make scientific studies (1) of the life history of marine borers from their larval stages through adult life, (2) of the distribution of marine borers, and (3) of techniques to test specific poisons which will protect timber and destroy marine borers.

These studies have been in progress since November 1948, and some of the results of the investigations have been reported to the Office of Naval Research. These reports indicate that steady strong winds, currents and tides carry the larvæ great distances along the seaboard, and for some distance out to sea. Four by four inch timbers placed in waters alongside lightships, 50 miles off shore, were completely destroyed in four months by marine borers.

While it is true that a harbour may be comparatively free of these organisms for years, yet a strong wind may suddenly sweep millions of larvæ into a harbour to infest the waters. Inactive wooden boats which are not anchored in areas removed from wood piling, or not in fast flowing rivers, can be rendered useless in less than six months if the waters are infested.

The breeding of marine borers occurs in all months of the year but especially in the early summer and late autumn. Within 48 hours after the birth of the larvæ, if timber is within reach, they crawl over the wood surfaces and in the next 24 hours they attach themselves to suitable wood with a sticky secretion, and within the next 72 hours their siphons are functioning and penetration is underway.

Marine borers seem to propagate and grow faster in temperate waters and especially in places near sewer outfalls. They are also in greater abundance in waters near timber structures and at the mouths of rivers.

Model Investigations of Aberdeen Harbour

(continued from previous page)

harbour. The wave height in the North Sea is measured on a scale graduated from still water level and waves 15-ft. high (based on the vertical scale) have been produced by the wave generator. Wave heights in the Fish Dock, or Albert Basin have been estimated with the aid of pointer gauges attached to micrometer heads. The micrometers read nominally to 0.001-in. and one of them is used for measuring the crest; the other for the trough of the wave. The zero readings are established by adjusting the pointers to touch a still-water surface.

More elaborate wave-measuring devices are contemplated for later tests. Meanwhile, it is found that these simple " visual methods " are adequate for preliminary or exploratory experiments.

Marine Borer Research—continued

Intensity of Marine Borer Attack in relation to the Velocity of Water Currents in and near Miami, Florida.

Number of borings per 100 square inches of experimental panels

(Period April 9—May 9, 1949)

Average velocity of currents in knots	0.13	0.15	0.19	0.25	0.35	0.50	0.80	1.50
Shipworms								
Top panel ...	2	7	6	5	4	2	0	4
Side panels ...	4	7	9	9	16	8	5	0
Bottom panels	283	327	314	272	214	113	51	4
Limnoria								
Top panel ...	20	129	97	106	24	22	11	14
Side panels ...	21	42	48	39	38	12	28	11
Bottom panel	84	147	86	81	24	13	5	4

Source: Bureau of Yards and Docks, U.S. Navy.

The *Teredo* is most active from September through November, the *Bankia* and *Martesia* in December, and the *Limnoria* from from June through November.

Marine borers usually prefer to attack the bottom of the experimental panels. They thrive in waters whose currents are not in excess of 0.35 knots; but as the velocity increases, the activities of the borers decrease. This was also found to be equally true of fouling organism.

To reduce borer attack, all old damaged timber should be removed from timber dock areas as quickly as possible. Creosote treated wood, it was found, liberates in salt water a soluble toxic substance which is harmful to marine borers, and in this connection, in is interesting to note that this toxic substance is less harmful to adult borers than to larvæ. In some ways, the effectiveness of this toxic substance was found to be comparable to the copper pigment in anti-fouling paints.

Wood treated with ciprinol up to 3 per cent. retention of copper, was attacked by borers in less than one year. In contrast, 16 pound creosote treated blocks were untouched.

Intensity of Fouling Organisms in relation to Current Velocities, Miami, Florida.

Number of Organisms per 100 square inches of experimental panels

(Period June 1—29, 1949)

Average velocity in knots	0.15	0.18	0.20	0.30	0.40	0.60	1.10	2.20
B. amphitrite								
Top panel ...	—	308	242	169	96	84	103	20
Side panels ...	—	256	177	169	138	101	57	16
Bottom panel	—	171	69	48	45	45	30	4
B. improvisus								
Top panel ...	—	44	32	14	23	29	23	8
Side panels ...	—	66	42	31	28	30	23	4
Bottom panel	—	41	23	13	13	45	17	0
B. eburneus								
Top panel ...	—	13	15	0	0	0	0	0
Side panels ...	—	16	17	23	4	4	0	0
Bottom panel	—	30	8	5	0	0	0	0
Chthamalus fragilis								
Top panel ...	—	7	5	2	0	3	3	0
Side panels ...	—	5	2	1	0	0	0	0
Bottom panel	—	1	0	0	0	0	0	0
All barnacles								
Top panel ...	—	371	294	185	119	116	127	28
Side panels ...	—	344	232	225	170	136	80	20
Bottom panel	—	243	99	66	57	90	47	4
Schizoporella unicornis								
Top panel ...	—	253	258	246	142	37	27	0
Side panels ...	—	340	312	252	182	59	0	0
Bottom panel	—	57	24	0	9	0	3	0

Source: Bureau of Yards and Docks, U.S. Navy.

Studies are now being undertaken to determine the effects of wood treated with ferric chloride followed by ammonia, with ferrous sulphate followed by ammonia, and with hydroxymercury and similar metallic compounds. At the same time, studies are being made to determine the loss of toxic properties when subjected to accelerated leaching conditions.

Rat Elimination in Ships

Search and Fumigation

By J. G. McCOY
Chief Port Health Inspector, Liverpool.

Plague is a disease that may be contracted by man through the bite of fleas, which have fed on infected rats; therefore one of the functions of Port Health Authorities throughout the world is to try and prevent the existence of rats in ships; and in particular, to prevent any plague-infected rats from other countries entering ports.

At the International Sanitary Convention of Paris, 1926, it was decided that " all ships, except those employed in national coastal service, shall be periodically deratised or be permanently so maintained that any rat population is kept to a minimum."

Deratisation is an international word meaning rat elimination; and the best definition I have heard of " a minimum " is none.

Certificates of deratisation or deratisation exemption are issued by approved Port Health Authorities, and they are valid for a period of six months, except in the case of a ship proceeding to its home port, when the period may be extended by one month.

Before these certificates are granted, the ship must be searched for evidence of, or harbourage for, rats. It is advisable that all cargo should be discharged, the holds swept clean, and any dunnage wood left in the holds stacked off the deck, at least 24 hours before the search takes place. This is not always convenient, especially when vessels are loading and discharging at the same time, but where possible should be carried out.

Rat infestation in ships is almost always due to the " ship " rat (Rattus Rattus) or to mice; the common or brown rat (Rattus Norvegicus) seldom goes to sea; and fortunately most ships are now entirely free from rats.

The searcher should wear overalls and carry a torch, and when engaged in a ship where plague is suspected, wear rubber boots or leggings covering his ankles, and gloves with gauntlets covering his wrists.

Ships should always be searched during daylight hours, and hatch covers at each side of the ship should be removed to give maximum light in the cargo holds. The searcher should report himself to the officer in charge of the ship and during his search be accompanied by a member of the ship's personnel, who can open locked doors, lift hatches and limbers, turn over stores, and generally be of assistance. Searchers usually proceed systematically through the entire ship, commencing at the fore peak and forecastle space, then cargo spaces, store rooms, galley and pantry, engine room and shaft alley, accommodation and all the upper structure of the vessel, and finally lifeboats, making notes of what they see, with a separate estimate of the number of rats in each space. The evidence is reported as " none "; " slight " (less than six rats); " moderate " (between 6 and 20 rats); or " pronounced " (over 20 rats).

Live rats may be seen during the search, but as rats are mostly out of sight, the searcher may see the same rat several times, and unless there are large numbers it is merely additional evidence that they are present.

Sick or dead rats, without visible marks of injury, are an indication of plague. They should be labelled as " suspected " and sent immediately to the bacteriologist for examination. All dead rats should be dipped in paraffin oil, and suspected rats should be handled with care. Old and dried carcases indicate a past infestation.

Rat excreta or " droppings " are the principal guide to rat infestation. They are rod shaped with rounded ends, are dark in colour, and vary from $\frac{1}{4}$-inch long by 1/16-inch in diameter to $\frac{3}{4}$-inch long by $\frac{1}{4}$-inch in diameter; when fresh, they are soft and glistening in appearance. The droppings vary with diet, and this also influences the number of droppings passed; thus the expert searcher can tell from the appearance of the droppings what food

Rat Elimination in Ships—continued

the rat has probably eaten, and therefore how many droppings the rat should have left during the previous 24 hours. After 24 hours the droppings commence to harden, and after two or three days become hard, dry, discoloured and sometimes dusty. In making an estimate of the number of live rats present, it is advisable to ignore stale droppings. In some spaces in a ship, such as the forepeak store room, there may be considerable condensation, making old droppings look fresh; and in other spaces, such as the galley, where it may be hot and dry, fresh droppings may appear stale—some experience is required in making an accurate estimate. Mouse droppings closely resemble those of rats, but are much smaller.

In addition to droppings, the searcher looks for runways or body marks. The ship rat, which is an excellent climber, prefers to travel overhead where possible, and usually takes the same route, and as its body is dirty and greasy, it leaves behind marks which are quite distinctive.

Gnawings consisting of gnawed woodwork, old and new cuttings, are usually found. Another useful sign is tracks made in soft surfaces, such as coal dust or grain; feet and tail marks are often quite clear.

The smell of rats, particularly dead rats, is unmistakable. The searcher always looks for nests; if he misses one with a few young in it, his estimate may be wrong. They are often found in defective pipe casings, behind stacks of empty sacks or dunnage wood, or amongst undisturbed stores.

Rats may be anywhere in the ship, but the most commonly infested spaces are cargo holds, coal bunkers, and provision store rooms.

Rat harbourage may be temporary or permanent. Temporary harbourage usually consists of undisturbed stores, or gear not properly stowed, dunnage wood, and mats not properly stacked, or accumulations of refuse. Permanent harbourage may consist of openings into hollow or concealed spaces, or defects in structure through damage, or in design, permitting a rat cover and/or access from one space to another; defective pipe casings; telegraph casings; spaces under raised flooring; spaces behind wood-linings and under settees; or pipes passing through bulkheads, leaving apertures through which rats can pass. It does not follow that every wood lining or hollow space is rat harbourage; but it becomes so if the rat has access to it.

These defects should be corrected; old and useless gear should be disposed of; accumulations of refuse removed; all wanted gear should be stowed at least 18 inches above the deck, and chains and blocks hung up. Unavoidable openings should be screened with wire mesh, metal collars fitted round pipes passing through bulkheads, and gnawed edges of wooden fittings proofed with metal plates; defective wooden pipe casings should be replaced by skeleton metal ones, and access to hollow spaces sealed.

Once the search is complete, if no fresh evidence or harbourage is found, a deratisation exemption certificate may be issued. If it is apparent that rats or mice are present, the ship must be deratised.

In different countries, and even in different ports, the methods employed for deratisation vary; generally they consist of fumigation, trapping and/or poisoning. In my opinion, fumigation is the most efficient method in which one can be reasonably sure that all rats are destroyed.

The most common method employed when poisoning is to select a number of baiting points; pre-baits are then set for a number of days and the takes counted; then if it is observed that the baits are being taken, poison baits are laid and again the number of takes counted. Finally, post-baits are laid, so that the efficiency of the treatment can be assessed. Any residual rat population may be caught by using traps, or the poisoning process can be repeated, using a different poison and bait.

Trapping consists of setting large numbers of rat traps of the " breakback " type, or rat cages. The " breakback " type traps are finely set and usually laid at right angles to the rat runs, rat cages in line with the runs. Prior to bacteriological examination, the presence of dead or sick rats from poison may be confused with " suspected " rats, and when using poison and " breakback " traps it is possible that infected fleas could leave the dead rats.

Fumigation is always carried out if plague is suspected, to ensure an immediate and complete kill of rats and fleas. Fumigants for deratisation in this country are SO2 (sulphur) and HCN (hydrogen cyanide). The ideal fumigant should be very penetrating, deadly to rats, insects and their eggs, and yet be harmless to metals, fabrics and foodstuffs, easy to handle, detect and to clear, without danger to the ship or the operators, and require a short exposure. Neither HCN nor SO2 satisfy these requirements, although HCN does satisfy most of them. SO2 is only occasionally used, usually in circumstances when the ship's crew must remain on board.

An approved Port Health Authority may carry out fumigation themselves, or it may be carried out under their direction and control. A question that occasionally arises in the latter case is the amount of control a Port Health Inspector should have over a fumigation. He attends the fumigation, and although he accepts no legal responsibility for any accident, he must see it carried out to his entire satisfaction. The fumigation must be thorough and carried out with skill, following very careful preparation; and whatever the fumigant, it is most important that the spaces to be fumigated are reasonably gas-tight, and that the distribution and weight of gas used is carefully checked into each compartment, and finally, that the exposure is adequate.

SO2 is generated by burning sulphur in open buckets usually placed in trays containing water. To assist the sulphur to ignite, a handful of wood-wool soaked in methylated spirits is often inserted into the sulphur. When first lit the buckets of sulphur look very pretty as they throw up flames and sparks in the dark holds, but the inspector who stays to see the sulphur burning with a low blue flame, usually comes out of the hold choking and spluttering.

HCN was first used commercially as a fumigant for the destruction of " scale," a pest which ravages citrus trees. A tent was spread over the tree and HCN either generated inside the tent or pumped underneath it. Eventually citrus plantations in many parts of the world were being fumigated. Later the gas came into regular use for ship fumigation.

HCN fumigation is usually carried out to obtain a certificate of deratisation, or to destroy bugs, fleas, cockroaches, or any other pests that might infest a ship. If the fumigation is intended to destroy other vermin in addition to rats, then higher concentrations and longer exposures are required than for deratisation, and credit for the amount of gas used is shown on the certificate.

If rodent plague is suspected and a ship is full of cargo, the ship is fumigated with cargo in, and then a second time after the cargo is discharged, using a high concentration of HCN and long exposure on each occasion. Apart from plague, the ship is empty for deratisation, and one fumigation is sufficient.

Everybody engaged in fumigation with HCN should be fully trained in the use of a gas-mask and be competent to administer first-aid. The onset of HCN poisoning is rapid and in addition to the danger of inhaling gas, there is always danger of absorption through the skin, more particularly when the skin is wet with perspiration.

Fortunately, although HCN is a lethal gas, there are few casualties. As a liquid it may be sprayed under pressure directly into the space to be fumigated; or it may be contained in absorbent material in air-tight tins which are opened and the contents distributed as required. With the latter method it is often necessary for the fumigators to enter the space being fumigated to empty the tins. Imagine a great liner in complete darkness and silence, not even the drip of the tap, the atmosphere hot and muggy without any movement of air; tins of HCN distributed throughout the ship and the dark shapes of men behind the light of their electric torches, emptying the tins quietly, methodically, and without fuss.

One of the commonest mistakes of the raw fumigator is to fail to test his torch, or to apply anti-dim incorrectly on the eye-pieces of his mask; the eye-pieces mist or perhaps his torch fails —he cannot see, and sometimes panics. He must then be led out into the fresh air and safety, but the work, once started, goes on until the ship is under gas and so deratised.

Protection of London Against Floods

Review of Research into the Cause of Floods, Conclusions Reached, and Precautions Taken*

By ROBERT CHALMERS, O.B.E., B.Sc., M.I.C.E., M.I.Mech.E.

The protection of London from floods due to overflow of the River Thames is a very old problem.

The Thames Flood of January, 1928.

The occurrence which gave rise to the latest phases of that problem took place shortly after midnight of Friday, January 6th, 1928. It was recorded by "The Times" on January 9th in these words: "Fourteen lives are known to have been lost in the disastrous flood which was caused by the overflowing and bursting of the banks of the Thames early on Saturday morning. A large number of families at Westminster and elsewhere are homeless for the time, and much damage has been done."

The extraordinary nature of the event is perhaps exemplified by the fact that the same newspaper devoted nine columns of print and a whole page of photographs to description of the events and comment upon them. There was a feeling among Members of Parliament and others than an investigation was required into the causes of the flooding and the possibilities of preventing a recurrence, and at the instance of the Prime Minister there was summoned a conference of authorities which met at the Ministry of Health on January 16th, "to review the situation and to settle what action can and should be taken to obviate any recurrence of such loss of life and widespread damage as resulted from the recent disaster."

The Thames Floods Committee.

The Conference arranged for the appointment of a Committee "to examine in detail the matters discussed by the conference, particularly the broad causes of the disaster, the question of the probability of the recurrence of such an abnormally high tide as that of January 6th/7th, 1928, and the giving of warnings."

The Committee included the Hydrographer of the Navy, the Director of the Meteorological Office, a Chief Constable of the Metropolitan Police, and the Engineers to the Ministry of Health, the London County Council, the Port of London Authority and the Thames Conservancy besides the representatives of several Government Departments and Local Authorities.

The Committee in turn appointed a Technical Sub-Committee to which it referred several questions. Their Report, which was adopted at a second Conference of Public Authorities on February 29th, 1928, included a historical section in which it was stated that "Floods in the area of the present County of London due to the overflowing of the River Thames have a recorded history extending over many centuries. The years 1235 to 1242, for instance, witnessed a number of these inundations."

The Committee reported having been advised by their Technical Sub-Committee that, "On the information at present available, more cannot be said in explanation of the tide of January 6th/7th than that it was due to the combination of the following causes: (a) The spring tide, (b) the raising of the water in the Estuary by meteorological conditions in the North Sea, and (c) flood waters from the Upper Thames. The Sub-Committee expressed the opinion that the first two of these were the main cause, and that abnormal quantities of water coming down the river probably accentuated the height to an extent not then known.

One fact not stated in the Committee report is worth mention here; 22 square miles of the County of London are below the level reached by the high tide of January, 1928; and within that area 10 square miles are below the level of Trinity High Water, a height which the tide often attains in London. London, therefore, is daily dependent upon its flood defences, quite apart from exceptional high tides.

The Tides.

The first of the three causes of the flood mentioned by the Sub-Committee was "The Spring Tide." Real understanding of the tides began, of course, with Sir Isaac Newton, and a vast deal of scientific study has taken place since Newton's days, of the tide-generating forces resulting from the gravitational attractions of the moon and the sun and of the practical effects of those forces at many places on the earth's surface. Among the most useful data for study of the practical effects are the records made by automatic tide gauges.

In a fortnight's record from an automatic tide gauge, it is quite easy to distinguish the date to which each of these traces of a rise and fall belong, since the tide each day occurs at a later hour than on the previous day.

Several tide gauges more or less alike are maintained at various stations along the tidal part of the Thames at the London County Council, the Port of London Authority and the Thames Conservancy.

Wherever records of this kind are available for a period of years, the tide predictor can analyse them into a number of constituents, each representing the effect of one aspect of the forces resulting from the gravitational attractions and the complex relative motions of the sun, the earth and the moon, or the effect of some other regularly periodic force causing movement of the sea. From those constituents he can then build up predictions for the future. In the final stage of this process he represents each constituent at a given moment by the accurate setting of one element of a tide predicting machine. Then when all the elements have been set and the machine is started it produces predictions in the form of curves of rise and fall similar to those made by the recording gauge. The dependability of the results is a wonderful triumph of the human mind, and is still being improved upon.

Storms, of course, and some other meteorological forces causing movements of the sea, have no regular periodicity, and their effects cannot be included in the tidal predictions. Before coming to these meteorological effects, however, let us consider how the tidal motion of the sea affects the tidal portion of the River Thames.

Figure 1 is a diagram the length of which is shown as a very highly compressed representation of the river's 62 miles between Teddington and Southend. The vertical scale represents tidal heights in feet above or below Ordnance Datum, and each line on the diagram represents a profile of the water levels throughout the length at a given moment. We start with the moment of low water at Southend, about 8-ft. below O.D. at 8.21 p.m. on July 7, 1921. At 8.55 p.m. the tide at Southend had risen about 9-in. At 9.45 p.m. it had risen a further 3-ft. and so on until 1.32 a.m. when it had risen to a little over 10-ft. above O.D. The successive lines show how the river had been filling up, and now, at 1.32 a.m. the water at Southend is higher than at Tilbury, where it is higher than at Woolwich, and so on up to Richmond, so that there is a strong flow of water up the river throughout that length. At Southend it was now nearly high water, which occurred 36 minutes later, at 2.08 a.m., and was only 7-in. higher at a little short of 11-ft. above O.D. The next line is very interesting, showing, as it does, that at 3.30 a.m. the tide at Southend had fallen by over 2-ft., while at London Bridge it had risen about 7-ft. and had reached a height of nearly 14-ft. above O.D. — that is, nearly 3-ft. higher than the greatest height of Southend. How is it that a tide of only 11-ft. height at Southend can cause a tide of 14-ft. height at London Bridge? The reason is that, in order to fill up the river channel to the level of high water at Southend, a large volume of water has moved up the river. When it has reached at London Bridge the same height that it had at Southend, it is still moving and has the kinetic energy due to its mass and its motion. It must, therefore, continue to flow upwards by reason of that energy, and partly because the channel above London bridge had not yet been filled. But the cubic capacity of the channel above London Bridge is not great enough to contain the volume of water in motion, and as the channel is narrower and shallower it offers greater resistance to that motion. The energy of the moving water can be expended, therefore, only in raising the level. The process comes to an end because the water farther down the river is falling,

*Presidential address to The Institution of Engineers-in-Charge, October 1950. Slightly abridged and published by permission.

Protection of London Against Floods—continued

and so gravity puts a brake on the upward flow and presently reverses it. The consequence as a whole, however, is that high water level becomes higher and higher as the crest proceeds up the river.

If we now go back to the point at which we started, low water at Southend at 8.21 p.m., it will be seen that at the same moment the water at Tilbury was already lower than at Southend. Half an hour later the water at Southend had risen a few inches, while at Tilbury it had fallen still further, so that low water at Tilbury occurred about half an hour later than at Southend and was about a foot lower. The explanation is rather similar to that of the raising of high water. The continuation of downward flow due to the energy of water already moving is facilitated by the greater cubic capacity of the widening estuary; the speed of flow from Woolwich down to Tilbury is lessening because of the diminishing head of water behind it; and so more water flows seaward from Tilbury than comes down the river to Tilbury, and consequently the level at Tilbury continues to fall until the downward movement is overcome by the flow from the tidal rise at Southend. We do not have lower and lower low-water levels all the way up the river, because in the upper reaches the channel is too shallow to allow of this development.

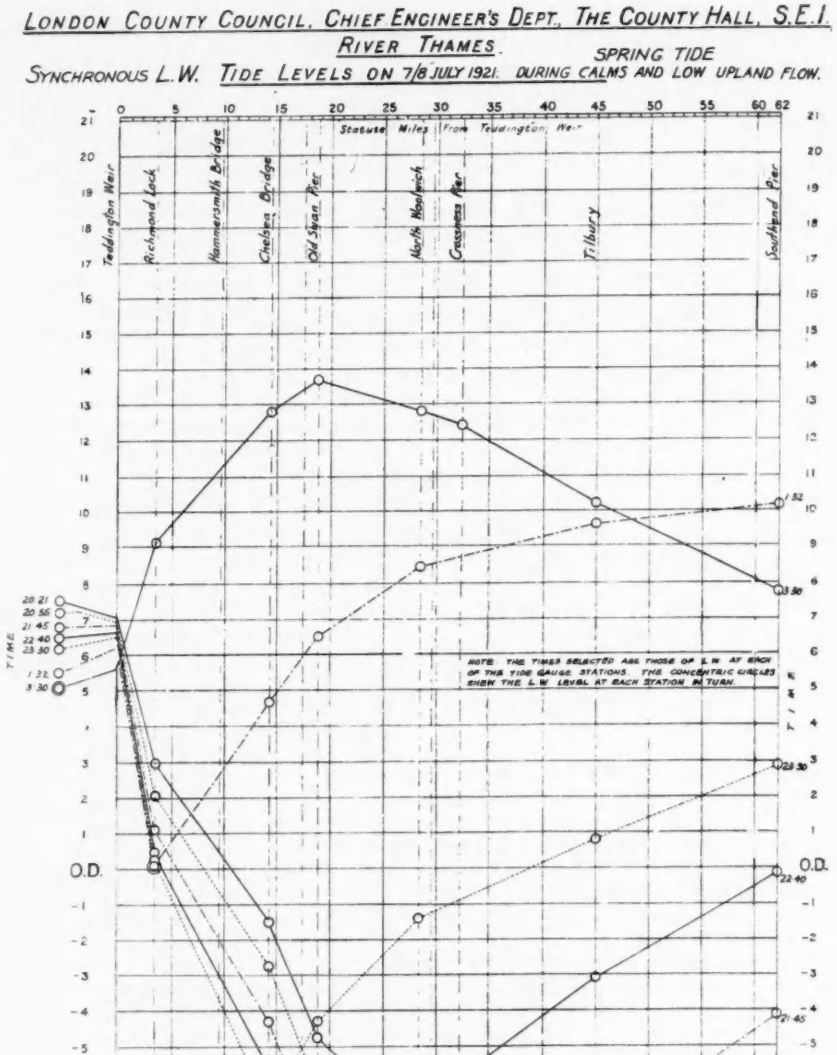

LONDON COUNTY COUNCIL, CHIEF ENGINEER'S DEPT., THE COUNTY HALL, S.E.1.
RIVER THAMES.
SYNCHRONOUS L.W. TIDE LEVELS ON 7/8 JULY 1921. DURING CALMS AND LOW UPLAND FLOW.
SPRING TIDE
Statute Miles from Teddington Weir
Teddington Weir
Richmond Lock
Hammersmith Bridge
Chelsea Bridge
Old Swan Pier
North Woolwich
Crossness Pier
Tilbury
Southend Pier
TIME
O.D.
NOTE THE TIMES SELECTED ARE THOSE OF L.W. AT EACH OF THE TIDE GAUGE STATIONS. THE CONCENTRIC CIRCLES SHOW THE L.W. LEVEL AT EACH STATION IN TURN.

Fig. 1.

Meteorological Disturbances of Sea Level. The Liverpool Tidal Institute Report.

The second cause assigned by the Technical Sub-Committee for the abnormal height of the tide of January 6th—7th, 1928, was "The raising of the water in the Estuary by meteorological conditions in the North Sea." The Committee endorsed their opinion that the whole subject of tides in the Thames required further expert investigatiion, and their recommendation that this should be undertaken by the Liverpool Tidal Institute in co-operation with the Hydrographic Department of the Admiralty and the Meteorological Office.

An investigation was commissioned accordingly by the London County Council and the Port of London Authority. Its results became available at the end of May, 1928, in a "Report on Thames Floods," by A. T. Doodson, D.Sc., Tidal Institute, University of Liverpool.

The Report explains that: "In order to determine the maximum meteorological disturbances of the tides it was necessary to consider all cases of large storm effects, whether at spring tides or neap tides, low water or high water, positive or negative," and this was done for the whole of the Southend tide-gauge records since 1911.

Fig. 2 will illustrate the meaning of the sentence I have just quoted . . . It shows by a dotted line the curve of the predicted rise and fall of the tide for Southend on December 31st, 1921, and by a full line the curve of actual rise and fall as recorded by the automatic tide gauge there. At high water, about 2 p.m., the difference is not large, but there is a very much greater difference during the preceding rise. In the absence of meteorological disturbances, the actual water levels correspond very closely with the predictions. The differences shown, therefore, are almost wholly due to meteorological causes, and in fact there was a remarkable storm at this time. The differences can be plotted on a horizontal datum line so as to eliminate the tidal rise and fall and obtain a diagram of the meteorological disturbance itself.

Fig. 3 shows this done for the same day and the preceding and following days. The resulting diagram shows that storm effects had lowered sea level by nearly 4-ft. about 8 p.m. on December 30th, raised sea level by 11-ft. about 9 a.m. on December 31st, and lowered it again by 3-ft. around midday on January 1st. Many surges, some of them illustrated in the Report by diagrams of this kind, had been examined by Dr. Doodson in relation to the types of barometric pressure system, the position and lines of travel of cylonic centres, and the time relations between the maxima and the storm surge and ordinary tidal oscillation.

The Report is full of interesting matter. It states that winds operating over the Atlantic Ocean are equally important with those operating over the North Sea. The popular assumption that water will be driven in the direction of the wind is shown to be erroneous. The rotation of the earth must be considered, and in deep water away from land the surface current is inclined at 45° to the right of the wind direction and the velocities of the lower layers are such that taking the whole of the fluid into considera-

Protection of London Against Floods—continued

tion the resultant transport of water is not in the direction of the wind but at right angles to it.

A westerly wind in the Atlantic will tend to lower sea level in the Thames, and a wind NW by N in the Norwegian Sea will tend to raise it.

One of the most effective winds in raising the level of the Thames is an East Wind in the Atlantic south of Ireland; because such a wind will cause transport of water, not to the west but to the north; the effect will then travel down the North Sea and ultimately the sea level in the Thames will be raised.

The other winds found to be most effective were NNW winds in the North Sea with a time lag of 12 hours and NNE winds locally, the effects being almost instantaneous.

Local winds, however, did not appear to be primarily responsible for large disturbances of high water heights, for whenever local winds appeared to be effective agents in causing a large disturbance of the normal tide motion the disturbance was greatest about two or three hours after low water. A reason for this is that winds blowing over shallow water are more effective than similar winds blowings over deep water; consequently strong winds blowing at the time of low water have greater influence than at other times, and the effects are manifested in the course of two or three hours.

Much evidence had been accumulated to show that a large part of a major tidal disturbance at Southend was due to a disturbance set up in the northern part of the North Set and propagated as a free wave down the east coast of Britain. Several such progressions had been noted, and in all cases examined there was a very marked time relationship of 8 to 10 hours between the times of maximum of the surges at Dunbar (on the east coast of Scotland near the Firth of Forth) and Southend. The surge that had caused the floods of January, 1928, was of this type.

The weather conditions in most such cases had been those in which a cyclonic depression forms west of Scotland and travels to the Baltic, the winds veering from SW to NW or N. The south-westerly wind is always accompanied by a fall in sea level in the Thames, followed by a rapid rise as the wind veers. The weather conditions accompanying the surge that caused the London floods were of this type.

We shall come back to Fig. 3 presently. Reference to Fig. 4 shows storm surges at Dunbar and Southend on January 12th—16th, 1916, and we can now see how this is interpreted in the light of the findings of the Report I have just tried to describe. On January 13th the surge at Southend has two peaks, the second of which follows a peak at Dunbar with an interval of 9 hours. Again, early on the 16th there is a peak at Southend nine hours after a peak at Dunbar. There is no peak at Dunbar corresponding with the first peak at Southend on the 13th. The first peak, however, occurs two hours after tidal low water at Southend. It is attributed to local winds, which, as we have been told, produce their greatest effect about two or three hours after tidal low water and are therefore not dangerous.

The second peak at Southend is attributed to one of the surges generated in the north, propagated as a free wave down the east coast of Britain, and observed at Dunbar some nine hours before they arrive at Southend. Their time of arrival is independent of the tidal rise and fall, and this one happened to arrive when the tide was about half-ebb and had fallen considerably from high water level. Therefore it was not dangerous. Similarly, the surge that travelled south on the 15th missed high water of the tide at Southend and caused no danger.

We now return to Fig. 3, which shows surges at Dunbar and Southend from December 30th, 1921, to January 2nd, 1922. The peak at Southend follows nine hours after a peak at Dunbar. But the peak at Southend is also just about two hours after low water there.

The explanation is that the local winds caused a surge the maximum of which, as in the previous case, occurred about two hours after low water of the tide; and a surge travelling from the north happened to arrive so that its maximum coincided with that of the surge locally generated. The two surges combined to raise sea level by 11-ft., but as this happened two hours after low water, the effects were not dangerous.

Fig. 5 shows storm surges of January 5th—8th, 1928, at Dunbar and Southend. On January 6th we see at about 4 p.m. a lowering of sea level at Southend of over 3-ft., attributed to south-westerly winds. As a cyclonic depression travelled eastwards, the winds veered to NW or N and a surge travelled southward along the east coast, showing its maximum at Dunbar about eight hours before its arrival at Southend at 11 p.m. In this case the arrival of the peak at Southend coincided very nearly with the time of high water of a spring tide, causing the predicted height to be exceeded 5.1-ft. We have seen that the height of high water increases as the tidal crest progresses up the Thames. The height of the surge is also increased in roughly the same proportion. This happened at a time when the Thames above Teddington was in flood, a heavy rainfall having fallen upon a frozen surface in the Thames valley, and unusually large quantities of fresh water were pouring over the weir there into the tidal portion of the river. The combined effect was an unprecedented high level of the Thames in London and elsewhere so that the flood defences in some places were broken down, and in many places were overflowed, with the disastrous consequences already referred to.

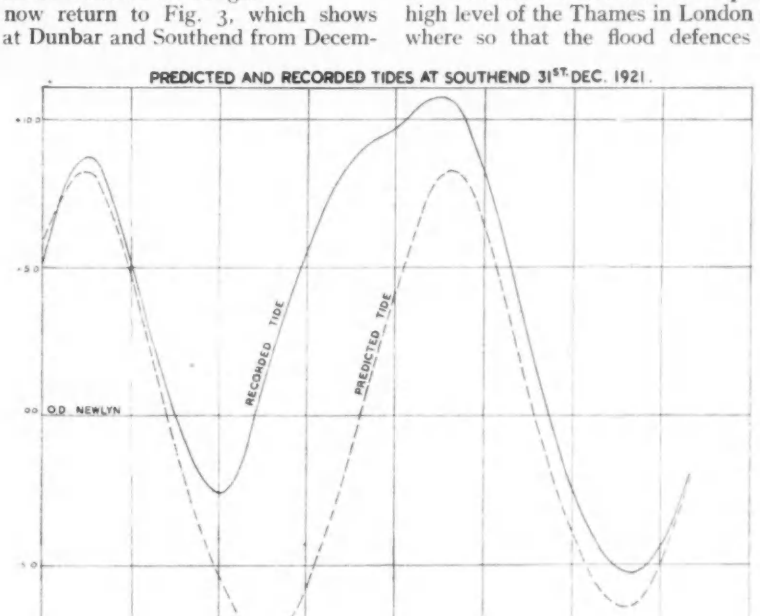


Fig. 2.

The discharge of fresh water over Teddington weir was at the rate of nearly 10,000 million gallons per day and Dr. Doodson considered this contribution to the water level. His conclusion was that the effect at London Bridge was a raising of the general level of the river by 0.8 to 1.0-ft., and " that the variations in land water are not of primary importance in connection with the possibilities of floods in London, though it has to be granted that one foot may make all the difference between safety and disaster if a storm surge is superposed with it on high water.'

" Part IV of the Report deals with the exceedingly difficult matter of the probability of recurrence. The final conclusion is that the probability of a flood, if it could be ascertained from sufficient accurate data, is not likely to be much different from 1 in 60 years. In other words, there is no reason to

Protection of London Against Floods—continued

expect floods to be more frequent in the future than in the past.

"The effects of raising the flood works have been estimated in two ways, and the conclusion is reached that if the defences are raised by 6-in. the frequency of occurrence will become, say, 1 in 120 or 180 years; and if the defences are raised by 1-ft. the frequency of occurrence will be reduced to, say, 1 in 240 or 540 years."

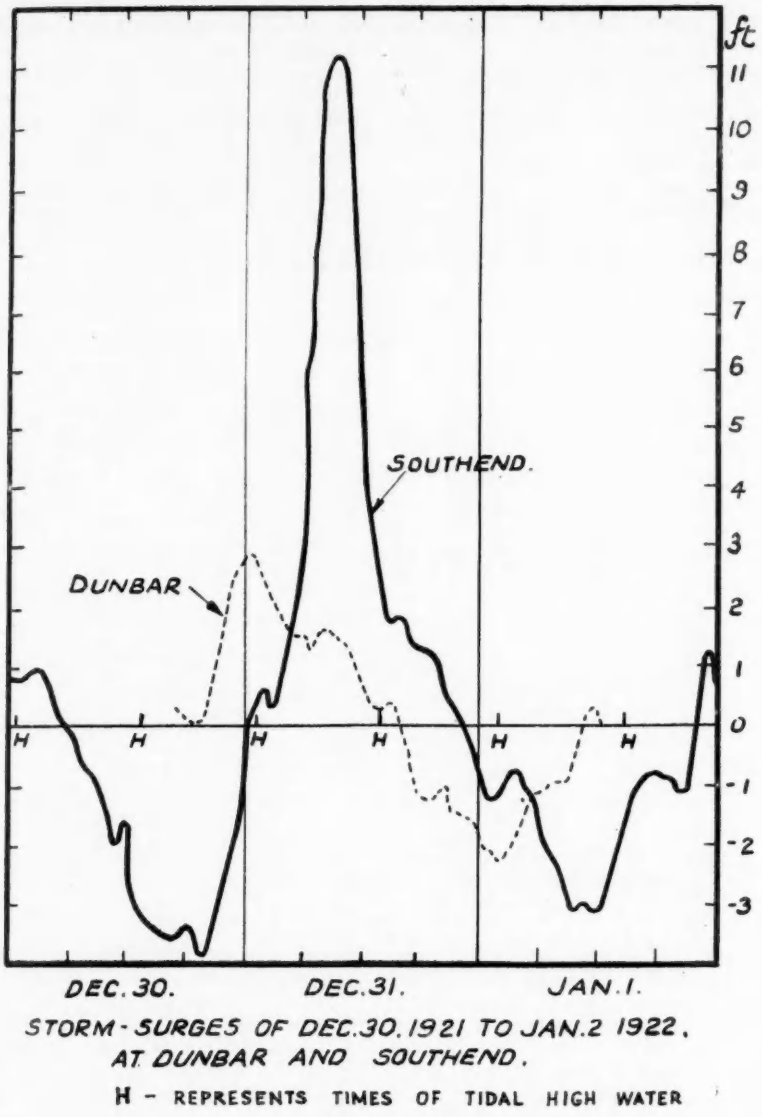


Fig. 3.

The Upper River Report.

The Thames Floods Committee had recommended that when the Liverpool Tidal Institute Report had been received the Engineering Advisers to the London County Council, the Port of London Authority, and the Thames Conservancy should consider the application of its findings to conditions in the part of the River above London Bridge.

Fig. 6 is a diagram which will illustrate the findings of these three Engineers. It is based on a contribution to their enquiries made by the Engineer of the Thames Conservancy. The horizontal dimension represents the 62 miles of river from Teddington to Southend, and the vertical scale is of tidal heights in feet from Ordnance Datum.

Line "a" represents the successive heights of high water of an average of neap tides as the crest travelled up the river at times when the fresh water discharge over Teddington weir was a minimum. Line "b" is a similar average when the discharge was at the rate of 10,000 million gallons a day. If a sufficient number of tides entered into the average, the difference between the two lines should give an indication of the effect of the high discharge over the weir.

Lines "c" and "d" are determined on the same principle but they represent spring tides under the two conditions.

Line "g" represents the levels reached by the tide that caused the flooding of London. Inspection shows it to be strikingly different from the others. It is almost a flat level from London Bridge to Richmond, where the others all show quite a steep rise. It was impossible to resist the conclusion that the tide that caused the flood would have risen even higher than it did, if the banks had been high enough and strong enough to contain it. If it had been contained, it must have risen to heights something like those shown by the line "gl" and, as the fresh water flow was about 10,000 million gallons a day, the effect of the fresh water would be something like the difference between line "gl" and line "h."

This diagram is only illustrative. Several methods were pursued, some by theoretical calculations, others by further examination of records. 10,000 million gallons a day had occasionally been exceeded and once doubled. The three Engineers thought they should not calculate for the possibility of a most extraordinary land flood coinciding with a most extraordinary tidal wave. They knew also that there had been overflows below London which must have reduced the height of water in London.

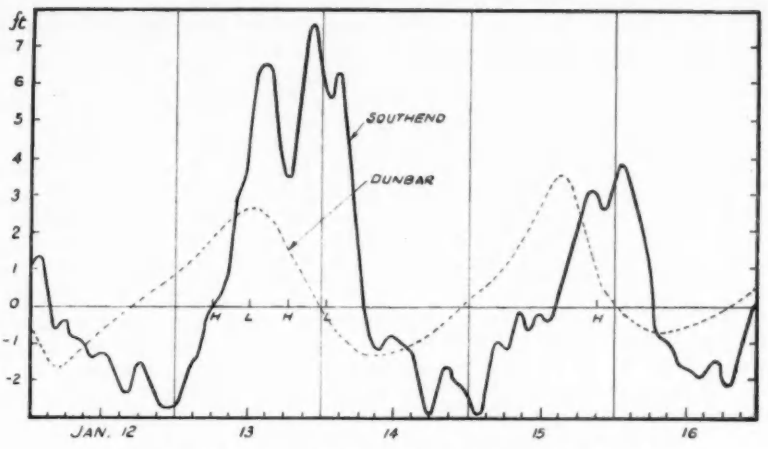
Assuming, then, that the discharge of the Thames over Teddington weir did not exceed 10,000 millions of gallons a day and assuming also that conditions below London Bridge would not be altered in any way that might reduce the relief afforded by overflow at times of exceptional tides, their conclusion was that the maximum height of the water to be expected in the river would be, at Hammersmith Bridge about 13-in., and at Richmond about 30-in. above the maximum height of the water at London Bridge. The figure for Richmond involved the further assumption of the river above London Bridge being embanked not only in London but also between Hammersmith and Richmond so as to prevent any overflow.

Practical Applications. (1)—London's Flood Defences.

The London County Council, as successors to the Metropolitan Board of Works, had, under an Act of Parliament of 1879, the function of settling the line and level of flood works necessary for effectually protecting all premises within the boundaries of the County of London, which in their judgment require protection from floods caused by the overflow of the Thames; and the execution of all flood works must be in accordance with plans prepared or approved by Council.

Following a high tide on January 18th, 1881, described by "The Times" as "calamitous," and which, breaking all previous records, reached a height of 17-ft. 6-in. above Ordnance Datum, the Metropolitan Board had fixed 18-ft. above O.D. as the standard level for all London's flood defences. The height of the 1881 tide had never been surpassed until 1928, and so the standard level remained at 18-ft. above O.D. The Thames Floods Committee considered it quite clear that there had been no reason to expect a tide of the magnitude of that of January, 1928, and that there was every reason to consider flood works of the standard height and of corresponding

Protection of London Against Floods—continued



STORM-SURGES OF JAN 12-16, 1916 AT DUNBAR AND SOUTHEND.
H - REPRESENTS TIMES OF TIDAL HIGH WATER
L - " " LOW WATER

Fig. 4.

strength as amply sufficient. On December 20th, 1927, only eleven days before the flood, there had occurred one of the highest tides on record and there was then no report of flooding, and the Committee regarded this as a testimony to the flood protection works of London. They recommended, in effect, that when the Report of the Liverpool Tidal Institute had been received, the Council should consider whether a general raising of the existing standard should be required.

The Council, in view of the magnitude and complexity of the questions which had arisen, arranged for the eminent Consulting Engineer, Mr. Frederick Palmer, C.I.E. (later Sir Frederick Palmer), to collaborate with their own Chief Engineer, Sir George Humphreys, in advising them.

In their Joint Report of June, 1929, on "The Future Standard of Thames Floods Prevention Works in the County of London," Humphreys and Palmer reviewed the history of the events which had led to the adoption of the existing standard. I have drawn freely on this section of their Report and on their review of the main data in what I have already said on these matters.

They also considered how far the exceptional height of water had been contributed to by works. The information available to them, while not conclusive, pointed to an inference that alterations in the estuary and river channel by dredging had had a negligible effect upon the level attained by an incoming tide below London Bridge. They inclined to the opinion that deepening of the river by dredging above London Bridge had been partly responsible for increased height of high waters above the Bridge. And they considered that the removal, in 1833, of old London Bridge, which had caused considerable obstruction to the ebb and flow of the river, had contributed in no small measure to a greater range of ebb and flow for some miles above its site.

They emphasised that the overflows that had occurred at the time of the flood, not only in London but also above and below, had released water which otherwise would have been heaped up to greater heights. Conversely, successive embankings and raising the level of embankments had reduced relief from overflows and had played their part in raising the levels reached by exceptionally high tides. If areas then subject to flooding were embanked, even higher flood levels would be experienced in London. They thought, however, they were justified in assuming that authorities outside London would not take concerted action at present in the way of generally raising flood banks.

They considered whether a more unfavourable combination of circumstances than that which had occured in January, 1928, should be provided for. This was a matter of judgment, and they were not prepared to advise that such provision should at present be made. They concluded, however, that it would be desirable to raise embankments in the County so as to provide a fair degree of immunity from damage should the conditions of January 6th—7th, 1928, recur.

With this end in view they recommended, "for the present," that the existing standard of 18-ft. above O.D. should remain from the eastern boundary of the County up to Bow Creek. Above that point the standard levels should be raised in two steps of 3-in. each up to London Bridge. From London Bridge to Putney Bridge the standard should be raised by 1-ft. and above Putney Bridge, by 1-ft. 6-in.

They made other recommendations which will be referred to later.

On March 18th, 1930, the London County Council fixed new standard levels for flood banks in the County of London in accordance with the recommendations of the Humphreys - Palmer Report. Without awaiting that Report, the Council had, almost immediately after the flood, instructed their Chief Engineer to make a special survey of all the defences in the County under their control. This was now well advanced, and works for the reinstatement of the defences that had been destroyed had been carried out.

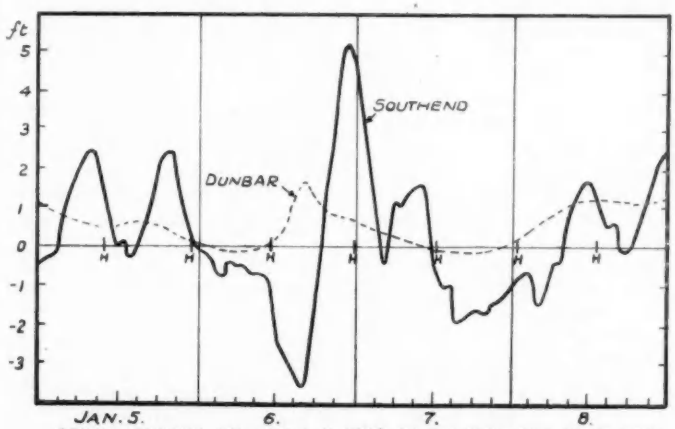
In scheming these works, allowance had been made, wherever possible, for the probability that raising would be required, and they had been made strong enough to ensure that the raising, if required, would be as simple a matter as possible.

Now that the new standard levels had been fixed, the survey and the scheming of works could proceed with the definite aim of bringing all London's defences to the standard heights, and of seeing that they were strong enough to resist a head of water up to their tops and that they were well maintained. The necessary works occupied some years, but they were completed before any tide approached the height provided for. When such tides did occur, the works were found adequate, and no flooding of London from the Thames has taken place since 1928. As Sir George Humphreys and Sir Frederick Palmer had forseen, however, and as we shall presently see, this does not mean that a permanent solution of the problem of protecting London from such floods has been attained.

In 1933, when bench marks related to the new Ordnance Survey levelling based on Newlyn Datum had become available, the London County Council, while adhering to the actual standard levels already fixed, redefined them by reference to Newlyn Datum instead of the old Ordnance Datum.

Practical Application. II—The System of Warnings.

The Thames Floods Committee considered it essential that an effective system of warnings should be instituted. Their Technical Sub-Committee defined the principles,



STORM-SURGES OF JAN 5-8 1928 AT DUNBAR AND SOUTHEND
H - REPRESENTS TIMES OF TIDAL HIGH WATER.

Fig. 5.

Protection of London Against Floods—continued

and the system as it presently took shape provided in the first place that the Meteorological Office should warn the Metropolitan Police and other authorities concerned when meteorological conditions indicate some risk of an abnormally high tide. Many of these warnings are not followed by danger, and they are therefore not made public, but they serve the purpose of an alert to the authorities.

The only reliable means of forecasting a dangerous high water in London was the actual occurrence of an exceptional height of water at Southend. The system provides, therefore, for a watch to be kept by the Southend Pier-Masters' staff on the Port of London Authority's tide gauge at Southend Pierhead. If the water there should reach the height of 12-ft. 6-in. above Ordnance Datum (which was the level known as Trinity High Water), the watchers would immediately notify the fact by Telephone to Scotland Yard. Automatic warning apparatus, ringing alarms in Police Stations at Southend and at Erith serve the purpose of precaution against any possible failure of warning from Southend Pierhead.

There are also six danger level marks elsewhere as far up river as Kew. The local police, notified from Southend or Erith, watch the tide in relation thereto, and give local warning in the danger areas in the event of the water reaching any of these levels.

When flood defences in London had been raised and made good to the new Standard Levels, the heights of water at which bells should ring and action be taken at the various stations had to be revised accordingly. With this exception the system remains in operation, as described, to this day. A good many warnings have come to London from Southend and Erith, but there have been only two occasions on which it has been necessary to warn people near the river.

Materials for Review.

The Thames Floods Committee suggested that the London County Council might consider it prudent to have a thorough review of the position at intervals. Since those days some materials for such a review have become available.

1. Relative Levels of Sea and Land.

The Humphreys - Palmer Report suggested that geological conditions might govern tidal heights, and drew attention to a suggestion that the surface of London in the vicinity of the river was undergoing a general lowering.

The London County Council's engineers were well aware, in 1928, that bench marks along the river were inconsistent and unreliable. The Ordance Survey were known to have a re-levelling of the country in hand, but could as yet supply revised values for only a few bench marks, so that in surveying flood defences the engineers had to do their own levelling over long distances from those few.

The Ordnance Survey had published an account of the primary stages of their re-levelling operations. One striking result was an apparent difference between the levels of the land as determined around 1916 and those shown by the first Ordnance Survey levelling around 1850. Along a line in the neighbourhood of Lancaster and Hartlepool the new levels correspond with the old; but differences between the old and new heights of the land surface increase with distance southward and eastward. There are differences of 3-in., 6-in., 12-in., 15-in. and 24-in. along lines passing through neighbourhoods respectively of Ribblesdale, Warwick, Daventry, Windsor, London and Harwich.

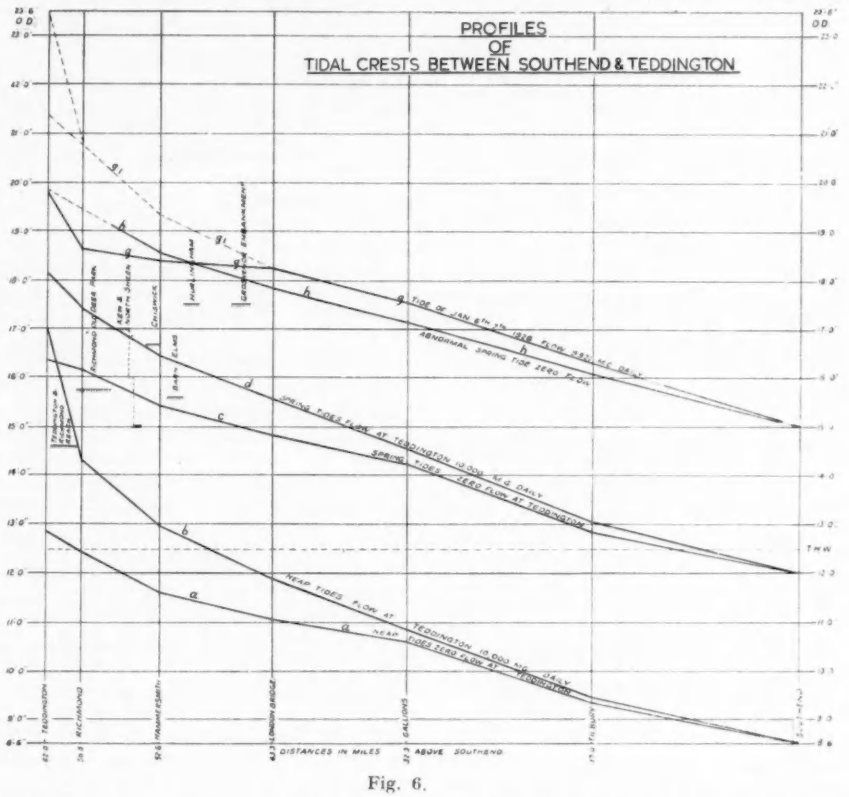


Fig. 6.

If both levellings were accurate, the result must mean that the surface of the country had tilted, and that while Lancaster remained approximately stable, London is now some 15-in. lower with reference to the sea than it was in 1850. The Ordnance Survey Authorities, however, inclined to the view that imperfections of the original levelling done between 1840 and 1860 were the main cause of the difference.

In 1932, Captain T. E. Longfield, R.E., of the Ordnance Survey, presented a Paper entitled " The Subsidence of London " to the British Association meeting at York, in which he suggested that apparent differences in height of land were only partly due to errors in the old levelling and that partly they indicated an actual general lowering of the land surface in the south-east of England. He also stated that " Borings have disclosed in the buried channel of the Thames the fact that what was the surface of the land in the Neolithic Age is now some 60-ft. to 70-ft. below mean sea level." This seems to correspond with geological evidence referred to in the Report of the Royal Commission on Coast Erosion, 1911, of a submergence of land, to an extent of about 60-ft. along the coast of England and Wales, which had been in progress in the days of Neolithic man, and an emergence of land in Scotland. The Report states that there was then no clear evidence that such movements were still proceeding. A supposition, however, that these movements have in fact continued, would appear to be consistent with their being the real cause of the difference between the two Ordnance Survey levellings.

Archaeological evidence comes from the observations of a Mr. Spurrell, who found on the margins of the Thames Estuary Roman remains, stubs of yew trees and traces of birch and hazel, all indicating what must have been dry land not so very long ago, now many feet under high tide. Dr. R. E. M. Wheeler, in the introduction to the volume on Roman London issued by the Royal Commission on Historical Monuments, supports Mr. Spurrell's view that the land near the Thames, including London, has gone down relatively to the sea. He adds evidence from Romano-British huts on the foreshore at Tilbury about 13-ft. below Trinity High Water, and he draws the conclusion that in Roman times the tidal limit of the Thames was in the neighbourhood of London, instead of at Teddington as now. Captain Longfield says " The evidence seems conclusive that the level of high tide 2,000 years ago must have been at least 15-ft. lower relative to the land surface than it is at present."

His tidal evidence comes from Felixstowe,

Protection of London Against Floods—continued

and he shows that mean sea level there rose, or conversely the land sank, about 2-in. in the 15 years from 1917 to 1932.

This is a very short period for these purposes. But there is evidence of a similar change over a much longer period at Sheerness. The observations there were supplied by the Hydrographer of the Navy for examination in connection with the Humphreys-Palmer Report which I have already mentioned. The examination showed that either mean tide level for 1913 was 6-in. higher than in 1836-41, or the dockyard there had been lowered by that amount in the interval of 75 years.

There is, therefore, a formidable body of evidence pointing to a long-continued and continuing lowering of the land adjoining the tidal position of the Thames. Whether or not it may be part of a more general subsidence of Southern England or of a tilting of Great Britain.

In addition to this suggested general subsidence, Captain Longfield showed quite conclusively that there is a rather more local, but still general subsidence in London wherever gravel overlying the London clay is thickly covered with streets and buildings. He suggested this might be due to water draining away from this gravel and carrying sand away with it. However that may be, there is a subsidence that affects the whole of London's flood defences except in Greenwich, Woolwich and Plumstead, and has amounted in some places to 4-in. or 5-in. in 37 years.

These subsidences then, some of them proved, others perhaps debatable, may be part of the reason why from time to time a tide occurs that breaks all previous records of height. The Thames Floods Committee Report mentions, with a reservation for possible errors in old records, a tide in December, 1663, noted by Samuel Pepys, stated to have been higher than any previously recorded, and reputed to have reached 16½-ft. above the level afterwards known as Ordnance Datum. This record, held till 1874, was then broken by 4-in. and that new record was broken by a further 5-in. the very next year, when a tide is said to have reached 17-ft. 3-in. above O.D. A further 3-in. was added in 1881, the height on this occasion being 17-ft. 6-in. above O.D. This record held until 1928, the year of the disaster which I mentioned at the opening of this account, when the tide broke the 1881 record by no less than 11-in. And, although the tide of 1928 was so much higher than any previous tide, yet its height has twice since then been practically equalled, in February, 1938, and in March, 1949. Each of these last-mentioned tides was actually higher at Southend than the 1928 tide. Neither, however, was accompanied by fresh water flooding above Teddington, otherwise there might have been some overflows in London despite the raised defences.

No doubt these successively greater heights are partly accounted for by the works of man as Humphreys and Palmer pointed out but, as they recognised although not in possession of all the evidence, changes in the relative levels of sea and land may also be an important cause.

II—Co-ordination of River Works.

One of the Humphreys-Palmer recommendations was : " That action be taken with a view of examining the advisability of co-ordinating all activities relating to the embanking of the tidal portion of the River Thames and the discharge of upland waters from the river and its tributaries."

In 1931, the Minister of Health and the Minister of Agriculture and Fisheries appointed a Departmental Committee with a reference: " To consider the present organisation for the prevention of damage by floods in the tidal portion of the Thames and to make recommendations as to the further measures, if any, that may be necessary, as to the Authority or Authorities to which the duty of carrying out any such measures should be entrusted, and as to the basis on which the cost should be distributed.

The Committee reported in 1933 (Cmd. 4452). They found that there was a medley of authorities sharing responsibility for preventing floods, with different kinds of powers, different methods of administration, and different ways of sharing the financial burdens. And, although works done by one might affect the others, each acted independently without obligation to pay regard to the effect of works on other parts of the area.

They recommended the constitution of a co-ordinating authority in the form of a Joint Committee of the existing authorities concerned. This committee should undertake a survey of the tidal basin as a whole; should employ such experts and obtain such advice as they might think necessary for a thorough investigation of the problem of flooding in the tidal basin, including the effects of storm surges and of suggested subsidences of land; should make such proposals for flood defence as they might think fit, leaving to the existing authorities the execution of the works; and should keep under review the ever-changing conditions in the tidal basin and prepare amended schemes as required.

The London County Council conveyed to the Ministers of the Crown concerned, their view that legislation to give effect to this scheme, with certain modifications, should be introduced at an early date. So far as I know, however, this action was not taken at the time nor since.

III.—Further Investigation of Storm Surges.

The further investigation of storm surges in the North Sea, indicated by the Liverpool Tidal Institute as desirable, and recommended by the Thames Floods Technical Sub-Committee and again by Humphreys and Palmer was, after a time, commissioned by the London County Council and the Port of London Authority with the co-operation of several Catchment Boards whose rivers, as well as the Thames, might be affected. It was carried out by Mr. R. H. Corkan, M.Sc., of the Liverpool Observatory and Tidal Institute, and was based upon a complete examination of the tide gauge records at Southend and Dunbar for the years 1928 to 1938 inclusive, and of the meteorological conditions associated with all surges of 2-ft. or more. It required an aggregate of about five years' work for its completion, and as the work was interrupted by the Second World War, the results became available only recently, in a Report by Mr. Corkan which records an extremely able and very valuable piece of research.

The Report* distinguishes nine fundamental types of surge, of which three produce lowering and six produce raising of sea level at Southend. Some are generated in the North Sea itself; others are generated externally and then propagated into the North Sea, where they travel southwards and are observed at Southend some nine hours after they pass Dunbar. Disturbances at Southend may result from surges of a single type or from a combination of surges of two or more types. Each surge type produces a characteristic disturbance at Southend and is associated with meteorological conditions which are more or less definite. So well has Mr. Corkan succeeded as almost to bring into view the possibility that, from known meteorological conditions, several hours' warning may be given of the occurrence of an exceptional high water at Southend and consequently a little later in London.

Conclusion.

The knowledge of storm surges now available is unlikely to be substantially improved upon for a considerable time, and may well provide the basis for a review of London's requirements for flood defence so far as the behaviour of the North Sea is concerned. The two main problems remaining to be solved for the purposes of a review seem to me to be: (1) the reality, continuation and extent of changes in the relative levels of land and water affecting liability to flooding, and (2) the means by which activities affecting flood protection along the tidal portion of the Thames may be co-ordinated.

Underwater Television Camera.

It was recently announced in Canada that scientists are developing an underwater television camera, which it is hoped, will make it easier for port authorities to examine harbour beds without using divers. The camera, which has been developed by the National Research Council, is now being tested on the Ottawa River in a research vessel. It is encased in a steel cylinder, and when it is lowered by cable into the water, a cameraman on board the ship can train the lens in any direction. The image picked up by the camera is transmitted to the television screen on the vessel by a co-axial cable. Remote control of the instrument has been perfected, but difficulties are still being encountered in solving the problem of securing sufficient light to enable the camera to record an image. A spotlight attached to the instrument is now being tested but this method does not appear to give sufficient light at great depths.

*See article in the February 1948 issue of this Journal.

Co-ordination in Cargo Handling

Excerpts from Speeches at Inaugural Meeting of International Committee

The Inaugural Meeting of the International Cargo Handling Co-ordination Committee (to which reference was made in our November issue) was held in London on 30th October last. Rear Admiral Mark Wardlaw, R.N., presided and delegates were present from Great Britain, France, Holland, Sweden, Belgium, Denmark, Italy and the United States. In his opening address, the Chairman said that the good attendance from all parts of the world indicated a wide and enthusiastic support, and after welcoming a number of the delegates by name, he then called upon Mr. A. C. Hardy, who, with M. Xavier Le Bourgeois, were the instigators of the scheme and who have been responsible for organising the Committee up to its present stage, and asked him to give details of the aims and objects of the proposed Committee.

Mr. Hardy thereupon outlined the historical background, and pointed out that as the work of cargo handling is essentially of international importance, the proposed Committee did not want to be tied up with one country or another, nor had they any ideas of usurping the functions performed by any existing institution or other organisation. Theirs would be solely a job of co-ordination.

Mr. Hardy then reminded the Meeting that, during February last, he sent a number of letters to the Press, calling attention to the general tendency for an increase in the speed of ships at sea, but at the same time, because of port delays, five fast cargo passenger ships were needed to-day to do the work that previously had been done by four. It would be remembered that about a year ago, Mr. MacGillivray read a Paper before the Institution of Naval Architects, in which he dealt with the inter-relationship of sea speed and port speed and gave details of some of the amazing devices which had recently been produced for the rapid handling of cargo. It was no exaggeration to state that many ship types could be built to-day which would be automatic in the discharge of their loads and sufficiently rapid in doing so as to enable them to co-ordinate their sea and port speeds. At the present time, shore equipment, particularly palletisation and fork trucks, now enabled a high rate of loading and discharge to be achieved with certain kinds of cargo. But most of the developments of this kind were localised, and there was neither standardisation of design nor co-ordination of knowledge and experience, both of which were essential if a naval architect, by what he put into the design of his ships, were to increase the speed of a ship's turnround in port. It was useless, for example, to have in a particular port a device which could remove cargo quickly from certain ships, but which could not handle others with equal celerity because hatches or side doors were inconveniently placed.

As a result of his letter to the technical press, the proposed Committee received many letters asking what could be done, and what were the terms of membership: " This was sufficient to encourage us to get together and to produce some Articles of Association. We are extremely conscious of the fact that these Articles are perhaps clumsy and ragged, but one has to start somewhere, and we felt that the sooner we go something into print to meet this demand the sooner we would get to our objective. I think that this Meeting to-day shows amply how successful we are likely to be. It is presumed that there is a need for the Committee, and we are really offering you the chance of joining and of taking an interest in the Committee to help what is nearest to all our minds, that is, the speedier handling of cargoes in ports."

Continuing, Mr. Hardy said that they hoped to elect an Executive Committee, and when that had been done, it was proposed that the first meeting of the Committee should be held in Paris towards the end of November. In the meantime, presuming that finance was forthcoming, the Committee would seek offices in London and appoint auditors to look after the finances. The Committee would also arrange for reports of future Meetings to be published, and it was proposed to try and arrange the first international Meeting, at which papers would be presented and problems discussed, some time early next year, the place of meeting being possibly Rotterdam, Antwerp or Genoa.

M. Xavier Le Bourgeois, representing the French Ministry of Merchant Marine, said that, in the opinion of the Committee, ships were not solely responsible for delays in ports. The ship was governed by the cargo, for she would stay one day or one week in port to load a given cargo, the length of stay being dictated by the nature of the cargo being handled. There was a growing tendency for ship construction to be governed by the nature of the cargo, which would seem to indicate that ships were losing their classical form and becoming more and more subservient to the cargo. The age of " any type of goods in any type of ship " was fast disappearing. We were, perhaps, living in a period of transition, and that might be the source of our troubles. It might also be that the remedy for delays in ports would be found in a higher specialisation of the packing and handling of equipment or the transport either on land or at sea.

Dr. Backx (Rotterdam) said that they, in Rotterdam, were very much interested in cargo handling. The discharge and handling of cargo had been done for the last 60 or 70 years in the same way; there had been some improvements as far as cranes and fork-lift trucks and such things were concerned, but handling itself had not changed very much. He thought this was due to the lack of a scientific approach to the problem, and perhaps this Committee could bring us one step further forward. The handling of cargo should be treated as one of the sciences of the world, and perhaps all our experience, put together, could build up this science. There were many things to be done. The first was to collect all the data needed. It was a curious thing that in the various ports of the world the same handling was done in different ways. Another thing which was very important, was the handling of the men, and in that respect, too, we could learn very much indeed from each other.

Mr. Donald Smith (Smith-Coggins, Ltd., Liverpool) said this problem was really immense and world wide. People were spending a lot of effort and a lot of money in designing pallets and trucks and equipment, and if they would only get together and standardise things at this early stage (because fork lifts, certainly in Europe, are in their infancy) they would have a marvellous opportunity. There were so many aspects of the problem—labour in particular, and getting them to accept new ideas in goodwill—that they must not try to cover every sphere to begin with. It was of paramount importance that they should settle an order of priority so that they could deal with problems stage by stage.

Mr. S. Svennberg (Stockholm) said that when he first came to deal with these problems, he had to conduct a research for his shipping company into the way its money was being spent, and he soon found that a great deal of money was being spent when the ship was in port. He thought perhaps this was something applying specially to his company, which was running ships in short distance trade on the Swedish coast, but when he looked up the official figures produced by an investigation of Swedish coastal shipping in the years just before the war, and took out the figures for Swedish trade along the coast in the Baltic Sea and the North Sea, he discovered that about 60 per cent. of all money spent and about 60 per cent. of all time spent was consumed in port. Later on he looked for further figures, especially for the coastal trade, and found that possibly 75 per cent. of cost was created in port.

He then thought that the best way to deal with the problem was to begin with shift working in harbour, but the people in Sweden would not agree. Then he had to find other methods, and thought that if it was possible to increase the results of what every man did, that would bring about a saving of money in the running of the ship, both for the expenses for the men and for the ship. These figures were about the same. Having got as far as that, he had found it impossible for one single company, owning one single harbour, to do anything without the collaboration of the other people concerned.

Later on there were formed in Sweden two committees. One of these was the Transportation Research Commission of the Royal Swedish Academy of Engineering Science, which was working along the same lines as Commander Hardy and M. Le Bourgeois propose. It had the same purpose, although it dealt with problems of cargo handling on the railway and truck transportation. The other committee was formed by an Association of the Harbour Boards. There were two rationalisation committees, one economic and one technical, and the technical committee had to deal with the problems of handling the cargo on shore as far as it concerned the construction of the port. They were now trying

Co-ordination in Cargo Handling—continued

to find out how to change the design of the harbour and the equipment so as to make it easier to run the ship. In a few months' time there would be put into service in Stockholm a new quay—really an old quay reconstructed—where it would be possible at the same spot to work with both the old and the new methods on the same ship, so that they could find out what methods are best.

Mr. G. C. v. d. Colk (Amsterdam Harbour Board) said that he was only present as an observer from the Municipal Harbour Board of Amsterdam. As was always the way with port management, they had to wait for private enterprise in the form of shipping companies and stevedores to solve the problems which needed solving. He would only like to emphasise this important point; the solution of this problem should not involve any capital investment. In any research into the economic principles of this problem they must look into the total costs of transport as compared with the total costs of the products, and the figure there was the very small one of 5 or 6%. He thought that even if they were able to obtain, from co-ordination, greater speed of discharge and loading, and a better comparison with sea speed they still would only gain from 1 to 4% of that transport cost. In his view the principal matter for study for the new Committee should be the important one of the savings to be made in this way, but he was sure that the gains would not be so great as to warrant important capital investments in the port as a whole.

Mr. Hildyard (Furness, Withy & Co.) said that when he visited two ships on the Continent during the summer, he was very impressed by what he saw. He asked how many men they required to put the cargo on board and to discharge it, and they told him that they needed a very small gang. That was an important point, because in England it would help a great deal. They had a stevedoring organisation in London, which had thought a lot about buying mechanical equipment, but when it came to the point, it was the number of men who were going to work it that decided the matter. In London to work a fork lift truck they still had to have the same number of men as if they had no trucks at all. He thought one of the greatest services, and some of the most valuable work that this new organisation could perform would be to create closer liaison between the unions and the employers, and if representatives from the Transport and General Workers' Union or the Stevedores' Union, could come to these meetings it would be an immense benefit.

M. Vincenti (Federation of French Stevedores) after pointing out that his organisation was not a union of the working people but of the employers, suggested that the Co-ordination Committee should comprise shipbuilders, stevedores, cargo-handling organisations and handling gear constructors, so that there would be a cross-section of all the cargo interests represented, because otherwise he did not think they could do any really useful work. France had the same problems as had been put forward by other speakers; and several French interests fully understood the need for co-ordination, and for speeding up the turnround of ships by every means available, and good results had already been achieved.

His last point, a very important one as far as France was concerned, was the question of representation of labour on the new Committee. He feared that there would be difficulty in getting labour to accept the principle of certain changes, to which Mr. Hildyard referred, and also in getting them to work within the proposed organisation. inasmuch as there was, within French labour circles a tendency to wish to be on an equal footing with the other organisations. That was going to create a great difficulty because on this Committee there could not be numerical equality, and it would be very difficult to get full co-operation because of this psychology. Also there was in France, and perhaps in other nations, a political question of immense difficulty which might hamper full co-operation on the Committee, at this juncture at least.

Dr. Luigi Accame (Maritime and Harbour Section, Genoa, Italy) seconded M. Vincenti's remarks regarding the participation of labour, and said that Italy was similarly placed as France, or perhaps its position was even worse. "An experiment was carried out in the way of a Co-ordination Committee between the ports of Marseilles. Genoa and Savona in order to avoid the terrific competition between the ports and to serve the general welfare. On that Committee representatives of labour, both from France and Italy, were asked to co-operate. These gentlemen came to the Committee, but instead of co-operating they mostly obstructed. The obstruction, of course, was caused mainly for political reasons. In the northern ports of Italy, for example, one can count on 80% of the dockers owing allegiance to the Communist Party. You can well understand what result that would give. Participation of labour on that Committee was just impossible, because information was passed on elsewhere which really ought not have gone there. This co-operation simply had to cease because it was absolutely unworkable. As far as Italy is concerned it would definitely be a very great problem to get the co-operation of labour in any way, because you would get not co-operation but obstruction."

Aerated Concrete

Advantages of New Building Technique

Aerated concrete is a comparatively new building material. It is already widely used in the Scandinavian countries and its production and use in the United Kingdom is increasing and it is becoming important that architects, engineers and builders should be informed of its possibilities and limitations.

Aerated concrete is produced by forming small bubbles of air or gas in the concrete mix so that the set concrete has a honeycomb structure. This is usually done either by adding to the mix aluminium powder which reacts with the cement to form small bubbles of hydrogen or by adding a foaming agent to the mixing water. By a suitable choice of mix, densities anywhere in the range of 20 lbs. to 100 lbs. per cu. ft. can be obtained, the choice depending on the purpose for which the concrete is to be used.

Aerated concrete has two major advantages, its lightness which makes it easier to handle, so helping to increase the speed of building, and its high thermal insulating value. The lighter products can be used for roofing screeds, the insulation of district heating mains, the construction of cold stores and other purposes where high heat insulation is essential but where strength is not important. Where more strength is needed, denser qualities have to be used. With good production and curing methods, for instance, blocks with a density of 55 lbs. per cu. ft. have sufficient strength to be used for the load bearing walls of two-storey houses. As with all light weight concretes, drying shrinkage tends to be high and care in production, curing and in methods of construction is necessary if troubles are to be avoided.

Development in Great Britain was held up during the war but has since proceeded rapidly. Research has been carried out to provide information on such matters as the best quality of aluminium powder to use, the production of a stable foam, the choice of sand as aggregate and the best methods of curing, so helping industry to produce a useful and reliable product.

An exhibit on aerated concrete was included in the Department of Scientific and Industrial Research Stand at the Building Exhibition, which was held in London last month. This exhibit explained the nature and properties of aerated concrete, and gave the technical information necessary for its successful use by the building industry. A new 16 mm. sound film on the subject was also shown daily in the D.S.I.R. cinema adjoining the Stand.

Mechanical Building Methods.

Visitors to the Exhibition also saw models which demonstrated the advantages of the Tower Crane for general building. These cranes are used to deposit regular supplies of materials at the hand of the bricklayer as he requires them. The roof framework and other units can be assembled comfortably and safely on the ground and be lifted into place in one piece.

No practical tests have yet been made of the method in this country, but it is estimated that by using the crane for most of the fetching and carrying of housebuilding, the time required for constructing traditional houses can be considerably reduced.

Other labour-savers for builders are machines which carry the whole of a concrete mix from the mixer to where it is wanted in one movement. These save the time and labour involved in wheeling concrete laboriously about the site in single barrowloads.

Port of London Annual Report

The forty-second annual report of the Port of London Authority for the year ended 31st March last, states that the total net tonnage of shipping which entered and left the port in 1950-51 rose to 54,313,846 tons. This was an increase of 4,065,295 tons on the preceding 12 months, though still below the pre-war traffic of over 62 million tons. Imports amounted to 35,998,911 tons compared with 32,597,761 tons in 1950 and 34,098,315 tons in 1939. Exports were 8,874,990 tons against 8,143,237 tons in 1950 and 7,563,748 tons in 1939. All the above figures include goods moved oversea, coastwise and trans-shipped.

The year's working produced a total revenue of £11,453,281 and a total expenditure of £8,836,748, leaving a balance of £2,616,533. After deducting various items and special appropriations there was a surplus balance for the year of £244,792, which, with a surplus of £342,180 brought forward from last year, left a surplus of £586,972 to be carried forward.

Considerable progress was made during the year in the provision of additional accommodation both for shipping and goods. Most of the work was concentrated on the restoration and improvement of damaged property, but major schemes involving new work were put in hand at the India and Millwall Docks and at London Dock.

The large increase in export traffic over the Authority's quays and changes in methods of handling traffic generally involved heavy expenditure in the provision of new cargo-handling equipment of many types. Some of the new methods are still in the experimental stage and the demand for further equipment is likely to be a continuing problem while the supply position remains difficult.

During the year the work of the Port was seriously delayed on several occasions by unofficial strikes which in the main were not connected in any way with conditions of employment.

Port of Liverpool Annual Meeting

At the Annual Meeting of the Mersey Docks and Harbour Board held on November 22nd last, Col. J. G. B. Beazley, M.C., T.D., D.L., Chairman, said that despite an increase in the traffic using the docks, the net financial result of the year ended July 1st last was not so good as in the previous year, owing to an increase in operational expenditure. The Board had, however, been able to contribute £188,000 to the Renewals and Depreciation Account and to reduce by £11,813 the deficit remaining from the immediate post war period, the deficit being now £237,520. The tonnage of vessels using the docks showed a small increase, and the tonnage of cargo handled during the year indicated a marked increase, particularly in the foreign export traffic which increased from 3,990,000 tons to nearly 4,500,000 tons. Exports also showed a marked and steady increase.

The major problem with which the Board were faced was the difficulty of clearing the quays and providing accommodation for vessels and their cargoes. Several factors entered into the problem such as shortage of shed accommodation due to war damage, problems of labour, working of road transport and many minor matters, but one factor of the utmost importance was that of the growing volume of export cargo handled through the port which owing to the longer occupancy of a loading berth than a discharging berth added to the difficulty.

The programme of shed reconstruction following war damage was proceeding steadily, the pace being governed almost entirely by the availability of materials, particularly steel.

The new shed at the North side, West Float, was now in full commission and proving very efficient, and while the new sheds at North 3 Alexandra and North Wellington were not wholly completed, certain sections were in use. They hoped to have the new shed at North 1 Canada in commission in the near future. Several additional new sheds had been authorised and provided the necessary steelwork was made available, every effort would be made to complete the work as early as possible. Nearly two miles of transit sheds had been constructed by the Board since the end of the war.

The new Langton-Canada Improvements Scheme was progressing in the face of difficulties which included a considerable amount of additional work required in the foundations as a result of bed rock being located much lower than anticipated from the available boring records. Here again progress was governed by the availability of plant and materials, and the Government had been made fully aware of the serious effect on the working of the Port if the completion of this Scheme was held up through lack of steel supplies.

Revised British Standards for Power-Driven Mobile and Derrick Cranes

The British Standards Institution have issued revised British standards for power-driven mobile cranes (B.S. 1757:1951) and power-driven derrick cranes (B.S. 327, Pt. 1:1951) and copies of both the new standards may be obtained from Sales Department, British Standards Institution, 24, Victoria Street, London, S.W.1, price 6s. each, post free.

Mobile Cranes

This is a new British Standard which has been prepared to deal with road wheel mounted and tracked power-driven mobile cranes, and it covers several different types, including both the full slewing, part slewing and non-slewing types which may be either fully mobile on their own wheels or tracks, or fully mobile and mounted on lorries. It also covers semi-mobile types and portable cranes.

This standard follows lines similar to the other crane standards by indicating minimum requirements with the intention of securing the general observance of such fundamental principles as are desirable to ensure reliability and safety without hampering the freedom of the crane makers in their selection of the most appropriate design. At the same time guidance is provided for the user regarding the types of crane covered by the standard.

The eight types of crane are described, and a number of the terms used in connection with them are carefully defined.

A feature of the standard that should be of considerable assistance to the majority of crane makers and users is the comprehensive nature of the clause dealing with testing.

Derrick Cranes

The fourth revision of this standard, which was originally published in 1928, follows similar lines to the previous editions in that it indicates the minimum requirements for power-driven derrick cranes of the normal type, and is intended to secure the general observance of such fundamental principles as appear desirable to secure reliability and safety without hampering the freedom of the crane maker in his selection of the most appropriate design for the purpose in view.

The standard does not, however, deal with hand-operated cranes which have been converted to power operation, but these are dealt with in B.S. 327, Part 2, "Derrick cranes (hand-operated)" which is now undergoing revision.

The standard deals with Scotch derrick, Guy derrick and Tower derrick types of cranes, and lays down requirements relating to the crane as a whole, including electrical equipment and provisions for testing.

In both the revised standards an appendix has been included dealing with stresses in structs and these follow the general method of the application of the Perry-Robertson formula which has been adopted in other appropriate British Standards. The additional appendix indicates a step in the evolution of the crane standards in that enquiries are being made into the question of permissible stresses in crane structures. It is probable, therefore, that before long it will be possible to issue a supplement in order to amend the standard to deal with stresses in the crane structure on similar lines to those followed in other British Standards, such as B.S. 449, "The use of structural steel in building," whereby the principle of using a factor of safety will be replaced by the specification of maximum permissible stresses, together with appropriate factors for their modification to suit operating conditions.

Manufacturers Announcements

NEW TYPE HAND-HELD POWER SAW

A completely new approach to power sawing was recently announced by the Wright Power Saw and Tool Corp., Stratford, Conn., U.S.A. As accurate and easy to handle as a handsaw, but up to 20 times as fast, the new 14 lb. saw operates from any 60 cu. ft. or larger air compressor.

Unlike conventional chain or circular saws, the new Wright Saw drives twin reciprocating blades over a 4-in. stroke at 1,500 strokes per minute. Yet because of the dynamic balance derived from the opposed motion of the blades, the saw is truly free-sawing; there is no thrust or torque, and no "kick" on completion of a cut.

Especially useful for heavy timber, there is no limit to the depth of cut, and the width of cut is limited only by the length of the 21-in. blades. Because of the novel tooth design, the saw is equally effective for cross-cutting, ripping or notching. Sawdust is thrown away from the operator and cannot clog or bind the blades. The teeth can be resharpened and set in the same manner as any handsaw.

Leading insurance safety engineers have endorsed the tool, since it is essentially as safe as a handsaw. The blades are a safe distance away from the operator, so that no guards are required—a feature that permits an unobstructed view of the cutting line.

Other features which contribute to the 90 per cent. time and labour-saving reported by users are: blades can be changed in seconds; handle adjustable through 360° for cutting in any position; because of the simple, rugged construction, the saw is virtually trouble free; saw stops instantly when spring-loaded throttle is released; finest alloy steel blades; saw can be stripped down or assembled in 3 minutes; low air consumption; aluminium alloy and steel construction.

Descriptive literature and name of the nearest distributor can be obtained from the address above.

NEW LIGHT BUOYS FOR NIGERIA

A demonstration test was recently carried out of a new type of light buoy.

These buoys have been designed to permit of 20° inclination to facilitate operation of the Admiralty pattern bell striking mechanism, and each buoy is equipped with lighting apparatus, comprising a 500 mm. diameter gas buoy lens and lantern. This lens is of moulded light-house glass. The lantern has a flasher mechanism inside with a burner — open frame type — and, together provides 550 candle power white light.

This will be seen in clear weather about 15 miles away. The flasher mechanism gives a single flash every ten seconds. Gas supply is from six gas cylinders mounted within the buoy. The supply gives over one year's unattended operation.

The lighting apparatus has been designed and manufactured by Chance Bros., Ltd.

The buoys have been constructed by Messrs. Brown Lenox & Co. (London), Ltd. and the superstructure is of a new design with a spherical daymark and lattice tower, the latter being fitted with cast steel shoes for connection to the top of the buoy. The focal plane is 15-ft. above line of flotation and in addition to this a radar reflector is mounted in accordance with the requirements of the International Safety at Sea Convention.

Eight 10-ft. diameter and eight 8-ft. diameter buoys are being constructed and these will be sent to Southern Nigeria where they will mark the entrances to the principal rivers and will be generally located about 15 miles out to sea.

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APPOINTMENTS.

TYNE IMPROVEMENT COMMISSION.

APPOINTMENT OF AN ASSISTANT CIVIL ENGINEER.

Applications are invited for the appointment of an Assistant Civil Engineer in connection with the design, maintenance and construction of dock and harbour works.

Applicants must be qualified persons having experience in the design and construction under contract and by direct labour, of structural steelwork, jetties, quays, railway layouts, buildings and other works appertaining to port installations. Applicants will be required to pass a medical examination and to become members of the Commissioners' Superannuation Fund. Commencing salary, according to qualifications and experience, will be on the scale £535 rising to £700 per annum (plus War Bonus at present £65 per annum).

Applications, stating age, education and training, professional qualifications, experience in the preparation of plans, contract particulars, and construction of civil engineering works, and giving the names of two referees, should be addressed to the undersigned so as to be received not later than 14th December, 1951.

J. K. McKENDRICK,
Secretary.

Tyne Improvement Commission.
Bewick Street,
Newcastle-upon-Tyne, 1.
7th November, 1951.

DOCK & HARBOUR MANAGER required, Middle East. Qualified Marine Superintendent with experience of Harbour administration, Cargo handling and Clearance. Knowledge Arabic an advantage. Salary £2,500 per annum, free house and messing allowance. Three year contract after probationary period. Send full particulars of experience, age, etc., in confidence to Chairman, John Howard & Company, Ltd., 13, Buckingham Gate, London, S.W.1.

DREDGER MASTERS.

Applications are invited from men having first-class experience of working large size stationary bucket dredgers in all materials, including rock. Ability to obtain maximum output is essential and only first-class men need apply. Applicants must be prepared to work either in U.K. or abroad and must be physically fit. Box No. 130, "The Dock & Harbour Authority," 19, Harcourt Street, London, W.1.

FOR SALE.

PORT OF BRISTOL AUTHORITY. ENGINEER'S OFFICE.

SELF-PROPELLED "AIRVEYOR."

The Port of Bristol Authority has for disposal One Self-Propelled "Airveyor" Portable Pneumatic Grain Elevator, by the Fuller Company, U.S.A. The plant comprises a Rootes blower of 20-40 tons per hour capacity, driven by a 115 H.P. "Caterpillar" Diesel Engine and mounted on pneumatic tyres as a trailer unit coupled to a General Motors Towing Unit powered by a 6 cyl. G.M. petrol engine, together with a quantity of 8-inch steel and flexible piping. Applications for forms of tender to be made to the Engineer-in-Chief, Port of Bristol Authority, Avonmouth Docks, not later than 7th December, 1951.

TENDERS.

ARGYLL COUNTY COUNCIL.

GOTT BAY PIER, TIREE RECONSTRUCTION AND EXTENSION OF PIER HEAD.

The Council will, in the near future, be prepared to receive tenders for the construction of a new tee shaped pier head of R.C. flat-slab construction, having a deck area of approximately 810 sq. yds.

Contractors wishing to tender should apply for Contract Documents to the County Engineer, Lochgilphead, Argyll.

A. D. JACKSON,
County Clerk.

County Offices,
Lochgilphead.
9th November, 1951.

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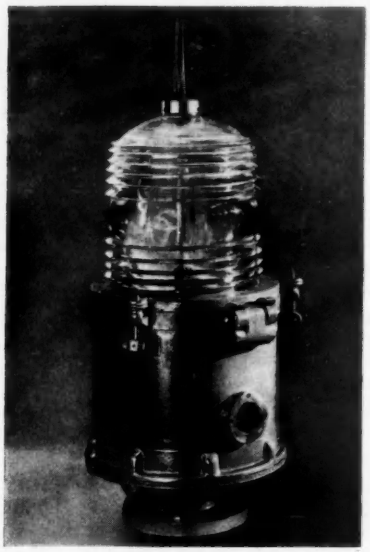

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